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Farmers' knowledge and perceptions of sustainable soil conservation practices in Paklay district, Sayabouly province, Lao PDR

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Abstract

In the agricultural areas in northern Lao PDR, maize production has become widespread due to intensive agricultural practices. As a result of intensive agriculture, farmers have been affected by soil degradation and increasing production costs. The farmers' knowledge and perceptions of sustainable soil conservation practices (SSCP) have influenced crop production. Importantly, soil conservation practices result in high soil fertility and decreased production costs. This study assessed the farmers' knowledge and perceptions of SSCP on maize production. A survey was conducted of 161 households in three villages (Palay, Boumlao-Phakeo, and Senphon) to gather primary data. Focus group discussions were also conducted to solicit additional data. Data analysis utilized a Knowledge Index and a five-point Likert scale. The results showed that 63 percent of the farmers interviewed were highly knowledgeable about SSCP while 32 percent and 5 percent had medium and low levels of SSCP knowledge, respectively. Regardless of the level of SSCP knowledge, farmers were conversant with the advantages and disadvantages of SSCP. However, farmers who had low levels of SSCP knowledge lacked practical application of soil conservation practices compared to those farmers with medium to high levels of SSCP knowledge. The survey results also showed there was a high level of perception of SSCP with 61 percent of the farmers interviewed positively agreeing with soil conservation practices. Nonetheless, despite the high perceptions of maize farmers in the study area, our findings showed a low take-up rate for SSCP practices. To improve the farmers' application of SSCP, the government and non-government organizations should provide a range of projects such as programs on the techniques of maize production and the technical practice of SSCP.

Introduction

In the highlands of the Lao PDR, the processes of overcultivation, deforestation, and overgrazing lead to accelerated soil erosion, the results of which are the most immediate environmental problem facing the nation at the present time. The major cause of land degradation is soil erosion that leads to low agricultural productivity.

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However, the dramatic problem of soil erosion has been significantly increased, mainly by human activity (Belay, 2014).

Farmers in the northern part of the Lao PDR, which includes the eight provinces of Phongsaly, Luang Namtha, Bokeo, Oudomxay, Houaphanh, Xieng Khouang, Luang Prabang, and Sayabouly which involve agricultural areas on steep slopes. In addition, the farmers in these areas have traditionally practiced subsistence agriculture for food. In the agricultural innovation period, farmers were quick to convert their traditional upland fields to cash crops production of sugarcane, maize, cassava, and rubber (Phanvilay, Thongmanivong, Fujita, Fox, & Center, 2006).

Maize production in northern Laos has increased due to the transition from shifting cultivation to intensive agriculture. As a result of intensive agriculture, farmers have been affected by soil degradation and increasing production costs. The main issue of soil degradation has been due to the high rate of chemical use and the lack of soil management practices. Poor soil preparation practices have also led to soil degradation and additional production costs (Jullien et al., 2008; Lestrelin et al., 2012).

Farmers' knowledge of sustainable soil management also differs, so farmers may practice different soil conservation techniques depending on their degree of perception and knowledge (Corbeels, Shiferaw, & Haile, 2000; Viengpasith, Yabe, Sato, Buguangbao, & Tengganshi, 2012). The farmers' lack of appreciation of knowledge and their perceptions of soil management are the reasons for the low adoption of recommended technologies (Okoba & De Graaff, 2005). Thus, this study investigated farmers' knowledge and perceptions of sustainable soil conservation practices. The results of the research should help to promote sustainable soil conservation in maize production where an increasingly high rates of chemical fertilizer, herbicide, and insecticide use have been observed.

Literature Review

In the 2000s, conservation agriculture (CA) was promoted in Sayabouly province as a possible means of achieving the agrarian transition while limiting the negative impacts of land use intensification. No-tillage agriculture associated with cover crops, crop rotations, and residue conservation have been shown to have positive impacts on soil erosion and on the maintenance or renewal (or both) of the soil's physical, biological, and chemical properties as well as on soil moisture conservation (Lestrelin et al., 2012).

Pesticides have been used since the colonial period in southern Sayabouly province when cotton production was promoted. However, the maize boom and associated agricultural expansion have greatly contributed to an increase in the local use of herbicides. The proportion of farming households employing herbicides has rapidly increased since 2005. In 2008, the distribution of herbicide use applied by the farmers themselves increased from 80 percent to 94 percent of the population on average for six study villages in Paklay district (Slaats & Lestrelin, 2009). In addition, a high rate of pesticide application (3.19 L per hectare) has been reported (Viengpasith et al., 2012) and farmers also burnt maize husks with a corresponding environmental impact although they had been trained in soil management practices such as conservation agriculture with an emphasis on natural soil fertility management, integrated environmentally friendly weeds, pest and disease protection, on-farm soil and water conservation techniques and farm-level seed conservation.

The restoration and preservation of the soil fertility status is an important strategy towards achieving sustainable soil management. Experience from the past showed that the farmers practice according to their current knowledge and that it is an important factor relating to their decision-making in sustainable practices. Farmers' knowledge of sustainable soil management also differs, so farmers may practice different soil conservation techniques depending on their degree of perception and knowledge (Corbeels et al., 2000; Viengpasith et al., 2012). The lack of appreciation by farmers of knowledge and their poor perception of soil management are the reasons for the low adoption of recommended technologies (Okoba & De Graaff, 2005).

This study aimed to assess the sustainable soil conservation practices (SSCP) in maize production. To achieve this goal, analysis focused on evaluating the knowledge and perceptions of farmers on SSCP.

Methods

Study Area

The cultivated farms in this study area were mainly located on sloping land where soil degradation is a common problem due to intensive maize cultivation. Three villages in Paklay district (Palay, Boumlao-Phakeo, and Senphon) were selected for this study because they have large maize-growing areas and furthermore, because farmland in these areas has been experiencing soil erosion that reduces crop yields, particularly in the rainy season. In addition, these three villages were supported by international funding and the Capitalization in Support of Rural Development Policy Program (PCADR), the Application Site Southern Sayabouly (PASS) and the National Agro-Ecology Program (PRONAE) to implement conservation agriculture. The projects supported materials, techniques, and methods of conservation agriculture. The lessons which were taught in the CA projects included intercropping, crop rotation, crop residue management, conservation tillage, and organic fertilizer use (Boumlao-Phakeo and Senphon villages in 2003 and Palay village in 2007).

Data Collection

Data on farmer's practices, knowledge, and perceptions of SSCP were collected using the participatory rapid appraisal technique (PRA) involving: 1) key informant interviews, 2) focus group discussion, and 3) interviews through semi-structured individual questionnaires for 161 householders.

Key Informant Interviews

Two types of key informant interviews were carried out with staff from DAFO and village headmen from Palay, Boumlao-Phakeo and Senphon. These interviews aimed to

understand the general context of each village, for instance, cropping systems, soil fertility management, and sustainable soil conservation practices.

Focus Group Discussions

Focus group discussions were organized in each village. Each meeting consisted of DAFO staff, the village headman, and maize farmers. The PRA method and its tools were used through a logical sequence of activities which began with crops production mapping followed by management profiling. It then moved on to an analysis of soil management systems and the seasonal calendar and ended with a discussion on the risks to the village with the current situation.

Household Survey

The emphasis of the study was on maize farmers who were involved in conservation agriculture projects and practiced soil conservation management. The content of the interviews was divided into two issues: assessment knowledge and personal perceptions of SSCP. These activities aimed to assess the level of knowledge and the level of perceptions of conservation agriculture.

Data Analysis

Knowledge Assessment

To assess the farmers' knowledge, 15 questions were asked requiring an answer of either true or false with a score of one (1) for the correct answer and zero (0) for the wrong answer. The farmers' knowledge was standardized by analyzing its content validity. After obtaining the Knowledge Index, the mean (μ) and standard deviation (SD) scores of all the respondents were classified into three categories. The respondents with scores in the range of (μ ± SD) were categorized as having a medium knowledge level and those scoring lower or higher than (μ ± SD) were categorized as having low and high knowledge levels of SSCP, respectively. The following formula was used to calculate the Knowledge Index (Jha, 2012):

$$\text{Knowledge Index(KI)} = \left(\frac{n}{N}\right)100 \quad (1)$$

where, KI = Knowledge Index. n = Total score of respondent for correct answers N = Maximum obtain score (15).

Farmers' Perceptions

To ascertain the farmers' perceptions, the study used a descriptive design. Data were collected via questionnaires with 20 questions. The questions were set requiring answers according to a 5-point Likert scale, where the respondents were asked to assess their range of agreement on each question through the following responses: Strongly Agree (SA), Agree (AG), Neutral (NU), Disagree (DA) and Strongly Disagree (SD) with an assigned weighting of 5, 4, 3, 2, and 1 for positive statements and *vice versa* for negative statements. For each question, a weighted mean was obtained as follows:

$$\text{WM} = [(\text{fSA}^*5) + (\text{fAG}^*4) + (\text{fNU}^*3) + (\text{fDA}^*2) + (\text{fSD}^*1)]/\text{n} \quad (2)$$

where, MW = Weighted mean f = Frequency of answers for each scale n = Number of total responses Values 5, 4, 3, 2, 1 = Scale weighting.

This study of the perception analysis followed Bagheri (2010) and Bagheri, Fami, Rezvanfar, Asadi, and Yazdani (2008) which reported that for the terms of perception analysis, the means of all questions were categorized as follows: 5 = Strongly agree (SA), 4 = Agree (AG), 3 = Neutral (NU), 2 = Disagree (DA), and 1 = Strongly disagree (SD). Additionally, the mean categorized the level of the farmers' perceptions of SSCP.

Results and Discussion

Sustainable Soil Conservation Practices

Based on the focus group discussion and key informant interviews of the study area, a large number of farmer in the study area applied SSCP. They had been using some different practices of SSCP (promoted by PCADR, PASS, and PRONAE) on their farmland which consisted of intercropping, crop rotation, crop residue management, conservation tillage, and organic fertilizers. Some of them applied the SSCP in their neighborhood.

The results of the household survey showed that 73.30 percent of the farmers interviewed had already adopted some SSCP practices while the rest used traditional practices. Farmers' adoption of the SSCPs had the following frequencies: intercropping (100%), crop rotation (10%), crop residue management (60%), conservation tillage (10%), and organic fertilizers (3%).

Farmers' Knowledge of SSCP

Figure 1 reports the knowledge scores of the farmers on SSCP. The scores varied with the highest number of correct answers (92.5%) regarding minimal soil disturbance (through reduced or no tillage in order to preserve organic soil matter) and maintaining and improving soil fertility. The lowest level of correct answers was 37.9 percent where the farmers were asked if using more chemical fertilizer improved soil fertility for sustainable practices. Figure 1 also shows the knowledge score, percentage frequencies, and standard deviation of the correct and incorrect answers. The farmers' understanding of SSCP for maize was measured by asking 15 true/false questions, where each question related to the methods of sustainable soil conservation practice (see appendix). In addition, the results showed that the farmers' understanding of SSCP varied according to their knowledge and experience.

The total scores from the questionnaires ranging from 0 to 15 were classified into three levels: high knowledge, medium knowledge, and low knowledge. Table 1 shows the distribution of farmers' knowledge levels. All of the interviewed farmers had some knowledge of SSCP for their farms but at varying levels, with sixty-three percent of farmers having a high level of knowledge (11−15 score), 32 percent of the farmers had a medium level of knowledge (6−10 score), and only 5 percent of farmers had a low level of knowledge (0−5 score).

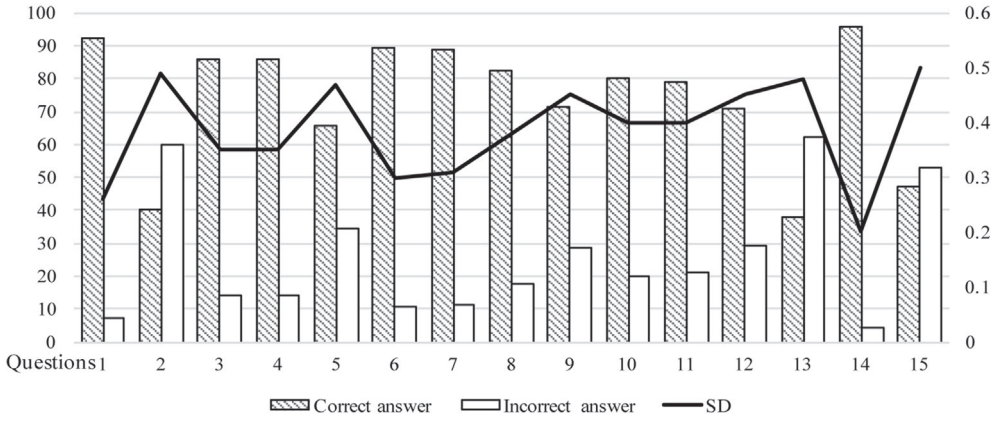

Figure 1 Farmers' knowledge of SSCP
Source: Field survey (2015)

Farmers with a high level of SSCP knowledge had a good understanding of the advantages and disadvantages of SSCP. Some of them were involved in the agricultural conservation projects although generally, the knowledge of SSCP had a good distribution to the wider area. Although some farmers were not involved in the agricultural conservation project, they also had some knowledge of SSCP. This group of farmers knew the benefits of SSCP methods for maintaining and improving soil fertility as well as SSCP practices.

Farmers with a medium level of SSCP knowledge had a good understanding of the benefits of SSCP but some of the farmers did not know much in terms of the necessary steps to practice SSCP, so they only practiced the methods that they knew well. They thought that applying SSCP methods was useful to reduce soil erosion, soil degradation, to control weeds, to save water when the rain came, and to maintain soil fertility for sustainable cultivation.

Farmers with a low level of SSCP knowledge were accustomed to traditional maize cultivation which they continued to practice. These farmers had an understanding of only a few of the advantages of SSCP and believed that SSCP was labor intensive.

The farmers with a medium score level and a low score level were not involved in the CA project. The farmers in these groups had some knowledge of SSCP in terms of increasing income and some of the advantages and disadvantages, but they had less knowledge of SSCP methods. As a result, they only applied a few methods, usually intercropping, on their land.

Table 1
Distribution of farmers' knowledge level of SSCP

Knowledge level	Frequency	
	Number	Percentage
Low level	8	5
Medium level	52	32
High level	101	63
Total	161	100

Source: Field survey (2015)

Farmers' Perception of SSCP

The farmers' perception of SSCP for maize production played an important role in farmers' adoption of SSCP. With a positive perception, the farmers improved crop varieties and soil conservation management techniques. The survey measured the degree of perception and compared between the farmers' perceptions and the farmers' practices. The survey measured the farmers' perceptions of SSCP in maize production. Farmers were asked to measure their perception level based on answering agree/disagree questions. The results showed that respondents had a strong positive perception of SSCP. Moreover, the majority of the farmers interviewed had the perception that SSCP depended on legume production followed by crop residue from maize and legumes.

The level of perception was measured by the responses to questions relating to improving soil fertility, reducing production costs (especially for chemical fertilizer), and increasing maize productivity. Some of them expressed that they did not have enough labor to practice SSCP and that they lacked experience in some methods of SSCP. This survey showed the differences in the farmers' perceptions of soil fertilizer management practices in maize production.

The survey instrument indicated two categories of agreement level on SSCP: agree and neutral. In terms of positive agreement, the farmers had the perception that applying SSCP could reduce production costs, help save the environment, and improve soil fertility by increasing organic matter use, reducing soil erosion, and getting more benefits from their land use in the long term.

On the order hand, some farmers had the perception that more labor was needed to participate in SSCP. They agreed that support from field units played an important role in practicing SSCP such as funding, training, and improving access to markets. In addition, they agreed that the practice of SSCP varied according to the farmers' attitude, land tenure (farmers who rented land for crop production did not practice SSCP) and farm size (SSCP was easier to practice on a smaller area). Some farmers had

good farming experience and a high level of education but did not practice SSCP. In contrast, some farmers had no experience with SSCP.

Farmers had a neutral perception to the suggestion that SSCP could increase crop yield and that the methods of SSCP were easy to practice in maize production. They also had a neutral perception to the suggestion that the decision to practice SSCP was affected by the ability to access outside information sources. Farmers were not familiar with the idea of discontinuing chemical use and instead replacing it with SSCP methods such organic fertilizer and soil covers Figure 2.

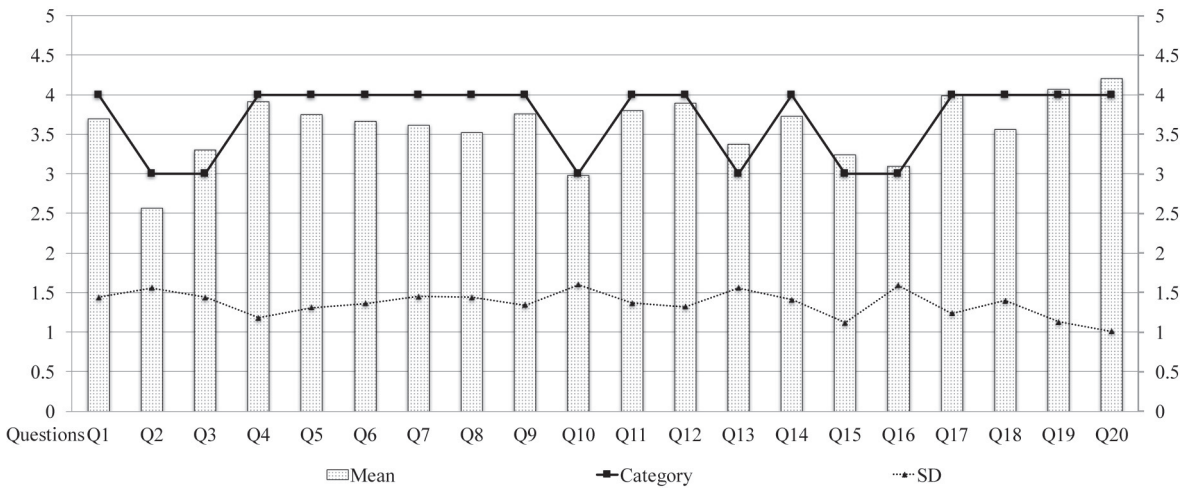

Figure 2 Farmers' perception of SSCP
Source: Field survey (2015)

The farmers' perceptions of SSCP were analyzed using a 5-point Likert scale. The agreement scores of each question were collected and then the mean of each question was categorized into a level. If the mean score was approximately equal or equal to 1, this was the strongly disagree level, if the mean score was approximately equal or equal to 2, this was the disagree level. A mean score approximately equal or equal to 3 was the neutral level, a mean score approximately equal or equal to 4 was the agree level and if the mean score was approximately equal or equal to 5, this was the strongly agree level.

As shown in Table 2, the levels of the farmers' perception indicated that 18 percent strongly agreed, 43 percent agreed, 14 percent were neutral, 22 percent disagreed, and 3 percent strongly disagreed. The perception of the maize farmers was high, but this was not reflected in the number of farmers who practiced SSCP.

Table 2
Distribution of farmers' perception level of SSCP

Perception level	Frequency	Percentage
Strongly agree	29	18
Agree	69	43
Neutral	23	14
Disagree	35	22
Strongly disagree	5	3
Total	161	100

Source: Field survey (2015)

Farmers' Knowledge and Perception of Different SSCP Practices

The chi-square test was used to estimate the relationship between the level of the famers' knowledge and perceptions of the five practices of SSCP

Table 3 shows the frequency of the most important practices regarding the three levels of knowledge, with the farmers in the groups who practiced intercropping and crop residue management having high levels of SSCP knowledge. Table 4 shows the frequency distribution of the level of perception, with the groups who practiced SSCP having a high frequency in the level of agree followed by the level of strongly agree, the level of disagree, the level of neutral and strongly disagree, respectively.

The chi-square analysis estimated the relationship between the levels of knowledge and the practices of SSCP in the study area. The results showed that there was no significant relationship between the level of the farmers' knowledge and the different practices of SSCP. There was a significant relationship between the level of the farmers' perception and the practices of intercropping, crop residue management, conservation tillage, and organic fertilizer at varying levels (1%, 5% and 10%), while the practice of crop rotation was not significant relating to the level of the farmers' perceptions (Table 5).

Cost of Maize Production in the level of knowledge and Perception

The results of the intensive practices in maize production caused soil degradation and additional cost. As reported by respondents, the main maize production costs

Table 3
The level of knowledge with the practices and management of SSCP

Level of knowledge	Inter- cropping		Crop rotation		Crop residue		Conservation tillage		Organic fertilizer	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Low level	1	7	8	0	2	6	7	0	7	1
Medium level	15	37	49	3	33	19	51	1	51	1
High level	27	74	92	9	55	46	91	10	99	2
Total	**43**	**118**	**149**	**12**	**90**	**71**	**149**	**12**	**157**	**4**

Source: Field survey (2015)

Table 4
Level of perception of SSCP practices

Level of perception	Inter- cropping		Crop rotation		Crop residue		Conservation tillage		Organic fertilizer	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Strongly disagree	5	0	5	0	5	0	5	0	5	0
Disagree	35	0	35	0	35	0	35	0	35	0
Neutral	3	20	21	2	17	6	23	0	23	0
Agree	0	69	63	6	30	39	62	7	68	1
Strongly agree	0	29	25	4	3	26	24	5	26	3
Total	**43**	**118**	**149**	**12**	**90**	**71**	**149**	**12**	**157**	**4**

Note: Yes = practice, No = not practice
Source: Field survey (2015)

Table 5
Chi-square analyses with practices to the farmers' perception

Practice	Pearson chi-square			
	Farmers' knowledge		Farmers' perception	
	Value	Asym.Sig.(2-sided)	Value	Asym.Sig.(2-sided)
Intercropping	.946	.623	147.673	.000***
Crop residue management	.390	.111	63.316	.000***
Crop rotation	1.169	.557	5.117	.275
Conservation tillage	3.478	.176	9.826	.043**
Organic fertilizer	3.486	.175	9.306	.054*

Note: *,**,*** Statistically significant at 10%, 5%, 1%
Source: Field survey (2015)

consisted of seed, land preparation, fertilizer, weedicides, pesticides, labor, and chemical spraying. These productions cost could explain the high production cost in maize production due to the level of farmers' knowledge and farmers' perception. Therefore, support for the technical aspects of SSCP is necessary for the farmers in these areas to improve their knowledge and perception of SSCP.

The findings in Table 6 shows that the farmer with a high level of knowledge of SSCP had production costs of USD 301 per hectare. Farmers with a low level of knowledge of SSCP had higher production costs of USD 329. Similarly, farmers who had perceptions of strongly agree, agree, and neutral tended to have lower production costs (USD 321, 298, and 285, respectively) than farmers with disagree and strongly disagree perception levels (USD 330 and 326, respectively).

Table 6
Average total production cost per hectare

Attribute	Production cost (USD)	
Farmers' knowledge	Low level	329
	Medium level	318
	High level	301
Farmers' perception	Strongly agree	321
	Agree	298
	Neutral	285
	Disagree	330
	Strongly disagree	326

Note: 1USD = 8,000 kip
Source: Field survey (2015)

Conclusions

The findings of this study showed that 63 percent of the maize farmers in the study area had a high level of knowledge of SSCP, 32 percent had a medium level and 5 percent of farmers had a low level. The farmers had different levels of knowledge regarding soil conservation which had important implications for sustainable agriculture. In this study, the farmers' knowledge was gained from their own experiences or observed from outside sources such as programs and projects. The results showed that the farmers with a high level of SSCP knowledge had been involved in the CA project. They had more knowledge of SSCP processes such as the methods and the advantages and disadvantages. They knew that applying SSCP methods helped to reduce soil erosion and soil degradation, to

control weeds, to absorb water when the rain came, and helped to maintain soil fertility for sustainable cultivation. The farmers with a medium score and a low score were not involved in the CA project. The farmers in these two groups had some knowledge of SSCP in terms of increasing income and some of the advantages and disadvantages, but they had less knowledge about the SSCP methods. As a result, they only applied a few methods, usually intercropping, on their land.

The results also showed that farmers had a high level of SSCP perception with 18 percent at the strongly agree level, 43 percent at the agree level, 14 percent at the neutral level, 22 percent at the disagree level, and 3 percent at the strongly disagree level. At the levels of strongly agree and agree, farmers understood that applying SSCP could reduce production costs, help save the environment, and the farmers could improve soil fertility by increasing organic matter and reducing soil erosion to get more long-term benefits from the land.

However, the famers' knowledge level was not correlated with their level of perception. Most of those regardless of the level of knowledge applied one or more methods of SSCP to their maize farms. Some of them practiced SSCP according to their neighborhood regardless of whether they had knowledge in each practice.

This study recommends that effort to promote SSCP on small-scale farms should focus on enhancement of farmer awareness of SSCP to improve the level of knowledge and the level of perception. There is a need to provide training and technical advice on SSCP through agricultural extension services, such as programs on the techniques of maize production and the technical practices of SSCP to increase the adoption of SSCP.

Conflict of Interest

There is no conflict of interest

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.kjss.2018.07.006.

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Appendix

A. Questions of investigation the level of farmers' knowledge of SSCP

1. SSCP is minimal soil disturbance through reduced or no tillage in order to preserve organic soil matter.
2. Practicing crop rotation, intercropping, no-tillage, crop residue and organic fertilizer together is SSCP.
3. Intercropping is growing more than one crop in an area at the same time.
4. SSCP is permanent soil cover (cover crops, residues, and mulches) to protect the soil against weeds.
5. SSCP is diversified crop rotation which promotes soil microorganisms and prevents pests and diseases.
6. Green manure involves soil incorporation of any field or forage crop while it is still green or soon after its flowering.
7. Mulches are residues from cover crops left on the soil
8. Cover crops are grown primarily to prevent soil erosion
9. Cover crops and mulches help to suppress weeds, provide additional organic matter and improve the physical and chemical properties of the soil
10. Crop rotation helps to improve or maintain soil fertility.
11. Crop rotation helps to reduce the spread of pests.
12. Crop rotation helps to reduce the risk of weather damage and increase net profit.
13. Applying more chemical fertilizer can improve soil fertility for sustainable practices.
14. SSCP leads to more herbicide use.
15. Reducing tillage and no-tillage saves fuel.

B. Questions of investigation the level of farmers' perception of SSCP

1. SSCP improves soil fertility for maize production
2. Farmers should stop chemical applications on maize production and change to SSCP.
3. SSCP can increase maize productivity

4. SSCP can reduce production costs
5. Farmers practice SSCP according to knowledge and experience
6. Farmers who rent farmland will not practice SSCP
7. SSCP requires too much labor for maize production
8. Decreasing the size of the cropland will encourage the farmer to practice SSCP
9. Decision to practice SSCP depends on the farmer's attitude
10. Farmers with more education will apply SSCP
11. Some farmers with a high education will not apply SSCP
12. Monitoring SSCP will benefit long term production
13. Information from other sources influences the farmers' decision to apply SSCP
14. Access to markets and the market price influences the decision to practice SSCP
15. If accessible training and funds are provided, farmers will conduct SSCP
16. SSCP methods are easy to practice
17. Practicing SSCP can improve soil quality and help save the environment
18. If they receive support from outside agencies and access to production facilities, farmers will practice SSCP
19. Some farmers with experience of SSCP do not practice SSCP
20. Some farmers have no experience of SSCP