Adoption of integration systems of rice and cattle in Serdang Bedagai, North Sumatra

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Abstract. The integrated rice and cattle system (SITT) is an innovative technology package to increase agricultural production and encourage zero waste fulfillment. The technology components introduced include new HYV, fertilization, young seedlings, organic fertilizers, Jajar Legowo, IPM, bio urine, and compost. Although it has been implemented at the farmer level, there are insufficient details of its adoption performance; therefore, it is necessary to measure the adoption to evaluate the technology dissemination. This research objective was to analyze the farmers’ adoption level, adoption period, and technology application frequency. The research was conducted in Serdang Bedagai, North Sumatra, in 2018. The respondents were 40 farmers (cooperator and noncooperator), and the respondents’ selection was made purposively. The data obtained were analyzed using qualitative and quantitative descriptive approaches. The results showed that the adoption of technology by cooperator farmers was higher than noncooperator farmers, both from the perspective of each technology component and the level of adoption. The average duration of technology adoption by farmers was 44.0% require more than one planting season, 28.4% require one planting season, and 27.6% require less than one planting season. The frequency of technology application showed that farmers who apply SITT technology more than two planting seasons were 66.0%, exactly two planting seasons were 24.5%, and one planting season was 9.5%. Thus, to increase farmers’ adoption of technology, the technology should be suited to farmers’ preferences and needs, increase profits and ensure that the technology is available in the field. Moreover, providing continuous assistance during the introduction of technology.

1. Introduction

Rice and beef are strategic and essential commodities because they have economic value and contribute to the economy, significantly contributing to Gross Domestic Product (GDP). Food consumption tend to rise in line with growth in the population. However, increased needs are not followed by production growth. The need for food, especially beef, tends to rise and is met by imports [1,2]. Efforts to increase food production are still facing various problems concerning the application of technology, the availability of production facilities, agriculture infrastructure, and climate changes.

Efforts to increase food production for rice and beef were carried out through the application of technology. One of them is through the application of technology through the Integrated System of Rice and Cattle approach, named SITT. SITT aims to increase agricultural production (rice and beef) based on zero waste. According to Winarso and Basuno [3], the purpose of the integration of crops and beef
cattle is to increase the population of beef cattle and, at the same time, crops productivity. Furthermore, the integrated system of rice and cattle is a farming system by applying the principle of zero waste [4]. As stated by Mukhlis et al. [5], the rice and cattle integration system is a farming system that combines two or more agricultural fields, based on the concept of biological recycling and input-output linkages between commodities with a low external input approach through the use of crop waste and livestock manure. This environmentally friendly system is to raise production and productivity, thereby increasing farmer’s income. Through an integrated system of rice and cattle based on zero waste could increase farmers’ income by 20.3% [6]. Other research stated that integration of crops and livestock is a farming model by synergizing between crop and livestock farming which is mutually beneficial to increase productivity [7].

To disseminate SITT technology, the Indonesian Agency for Agricultural Research and Development conducts SITT technology through the Rural Agricultural Development Model through innovation program, named MP3MI. The disseminated technology innovation is rice cultivation technology through the Integrated Crop Management (ICM) approach, including the use of new high yielding varieties (HYV), balanced fertilization, young seedlings, organic fertilizers, Jajar Legowo (Jarwo) planting system, and integrated pest management (IPM). Technology innovations that are being disseminated in cattle farming include bio urine technology and compost. Through this activity, it is expected that the adoption of SITT technology will occur widely to encourage an increase in rice and beef production. The crop (rice) and livestock (cattle) integration system contribute to the interrelationship between subsystems through the input-output flow between plants and livestock [8].

One of the MP3MI program locations that disseminate SITT technology is Serdang Bedagai District. Serdang Bedagai is one of the central districts for lowland rice in North Sumatra Province, together with Deli Serdang, Simalungun, and Langkat. The contribution of lowland rice production in Serdang Bedagai to North Sumatra production reaches 10.3% [9]. Rice production in Serdang Bedagai District is 480,739.60 tons, while rice production from North Sumatra is 4,669,777.50 tons. Apart from lowland rice, Serdang Bedagai also contributes to beef production in North Sumatra (6.2%). Beef production reached 1,621.77 tons, while beef production in North Sumatra was 26,297.65 tons [9].

From the description above, it is necessary to conduct research on the adoption of the SITT technology in the Serdang Bedagai District; moreover, there is inadequate information on its adoption performance. This study aims to analyzes the adoption, adoption period, and frequency of technology applications in SITT by farmers. The adoption performance, including adoption level, adoption period, and frequency of adoption of SITT technology, can be used as an indicator of the success of MP3MI implementation through the dissemination of SITT technology carried out by the IAARD.

2. Materials and methods

2.1. Materials
The research was carried out in 2018 in Lubuk Bayas Village, Perbaungan Sub-District, Serdang Bedagai District, North Sumatra Province, which is the location of the MP3MI program through the SITT technology dissemination activity carried out by the IAARD.

The research was conducted through a survey method. The data collected to support this research include primary and secondary data. Primary data is obtained through interviews using structured questionnaires to farmers as respondents. Secondary data is obtained from literature studies from research publications, reports from various sources, such as Statistic Indonesia, Assessment Institute for Agricultural Technology (AIAT), etc. The number of respondents was 40 farmers, consisting of cooperator and noncooperator farmers. Cooperator farmers participated in the SITT program, while noncooperator farmers did not participate in the program but live in the same village. The selection of respondents was made purposively (purposive sampling). The data extracted included the characteristics of farmers, the adoption of SITT technology by farmers, the adoption period of SITT technology by farmers, and the frequency of the application of SITT technology by farmers, rice production, beef production, and so forth.
2.2. Methods
Farmers’ characteristics include age, formal and informal education (training), farming experience (rice and cattle), number of family members, the main occupation of the farmer, the farmer’s primary income, and the farm size. Measurement of SITT technology adoption based on the Rogers classification of adoption includes knowledge, attitude, implementation, and confirmation [10]. Determination of the SITT adoption period is divided into three groups, namely less than one planting season, one planting season, and more than one planting season. The determination of SITT adoption frequency was also divided into three groups: one planting season, two planting seasons, and more than two planting seasons. Furthermore, data and information regarding farmers’ characteristics, technology adoption, adoption period, and frequency of technology adoption were analyzed through qualitative and quantitative descriptive approaches.

3. Results and discussion
3.1. Characteristics of farmers
Cooperator farmers have an average age of 49 years, while noncooperator farmers have an average age of 47 years, both are in the productive age (Table 1). Cooperators and noncooperators have low education (8 years), which are only elementary school graduates. Cooperators and noncooperators have attended training, and the frequency is relatively low, only two times/year. The training topic was integrated pest management. Although the average age, education, involvement in training between cooperators and noncooperators are almost similar, the adoption rate of SITT technology for cooperators is higher than noncooperators. Thus, those characteristics do not always positively affect adoption rates.

Cooperator and noncooperator farmers have quite a long experience in rice and cattle farming, 22 years and 17 years, respectively. It shows that farmers are very accustomed to farming. This long experience of farmers is a challenge in disseminating SITT technology because it can positively or negatively affect technology adoption. If the new technology aligns with the farmers’ habits, technology adoption tends to be easy. On the other hand, if it is not in line with the farmers’ habits, the opportunity for adoption will be increasingly difficult.

Table 1. Characteristics of farmers, Serdang Bedagai District, North Sumatra, 2018.

| No | Characteristics of farmers | Cooperator farmers | Noncooperator farmers |
|----|----------------------------|--------------------|-----------------------|
| 1  | Age (years)                | 49                 | 47                    |
| 2  | Formal education (years)   | 8                  | 8                     |
| 3  | Informal education, training (time per year) | 2                   | 2                     |
| 4  | Farming experience (years) | 22                 | 17                    |
| 5  | Number of family members (people) | 4               | 4                     |
| 6  | Main job as a rice and beef cattle farmer (%) | 82.4              | 73.9                  |
| 7  | Farmer income (IDR/month)  | 2,700,000          | 2,400,000             |
| 8  | Land area (ha)             | 0.8                | 0.7                   |

The average number of cooperator and noncooperator farmer family members is four people. Family members can be a source of labor from within the household, in several activities in farming activities. The involvement of labor in the household can reduce farming costs incurred by farmers. However, the allocation of labor for farming is lower than for non-agricultural activities [11].

Rice and cattle farming are the main jobs of cooperator and noncooperator farmers, 82.4% and 73.9%, respectively. The success of rice and cattle farming has a direct impact on the income and economy of the farmer’s household. The income of cooperators and noncooperators is IDR 2.7 million and IDR 2.4 million per month, respectively. Ownership of land by farmers is less than one ha, with the status of their own land. Land is one of the production factors in farming activities. The size of land ownership has a positive and significant effect on the opportunities for increased technology adoption [12,13,14], although Abebaw and Haile argues otherwise [15].

The characteristics of farmers are a reflection of farmer performance, which does not always positively affect technology adoption by farmers (level and distribution; time period; and frequency of
technology adoption). The proof is that education level and farming experience did not have a significant effect on the adoption rate [16]. However, as Akudugu et al. [17] and Abebaw and Haile [15] claimed, technology adoption tends to increase if education is high. Likewise, consistent with Bananiek and Abidin [18], the farming experience has a positive and significant impact on technology adoption.

3.2. SITT technology adoption level
The level of technology adoption is classified into four groups: knowledge, attitudes, implementation, and confirmation [10]. In general terms, cooperator farmers’ adoption of SITT technology is higher than noncooperator farmers. It occurs in each SITT technology component as well as at each SITT technology adoption level. The existence of program intervention allegedly the cause of high technology adoption among cooperator farmers compared to noncooperator farmers, where mentoring is carried out continuously during the program.

Table 2 shows that the highest percentage of cooperator farmers’ knowledge of the SITT technology components is HYV, young seedlings, and bio urine (85.7%). In comparison, the highest percentage of noncooperator farmers is HYV technology (57.7%). It also occurs at the level of attitude and implementation. It proves that the HYV, young seedlings, and bio urine are adopted by most cooperator farmers, while most noncooperator farmers only adopt the HYV technology. In harmony with research in Bangka Belitung, the technology with a high level of adoption was HYV and young seedlings [19].

Table 2. Farmers adoption level of SITT technology in Serdang Bedagai, North Sumatra, 2018.

| SITT technology components | Knowledge (%) | Attitude (%) | Implementation (%) | Confirmation (%) |
|----------------------------|---------------|--------------|-------------------|------------------|
|                            | CF | NCF | CF | NCF | CF | NCF | CF | NCF | CF | NCF |
| HYV                        | 85.7 | 57.7 | 85.7 | 57.7 | 85.7 | 57.7 | 85.7 | 57.7 |
| Fertilization              | 57.1 | 46.2 | 57.1 | 46.2 | 57.1 | 46.2 | 34.6 | 35.7 |
| Young seedlings            | 85.7 | 53.8 | 85.7 | 50.0 | 85.7 | 50.0 | 78.6 | 50.0 |
| Organic fertilizer        | 71.4 | 50.0 | 71.4 | 46.2 | 64.3 | 38.5 | 64.3 | 38.5 |
| Jarwo                     | 78.6 | 50.0 | 71.4 | 42.3 | 71.4 | 42.3 | 42.9 | 38.5 |
| IPM                       | 71.4 | 50.0 | 71.4 | 38.5 | 71.4 | 38.5 | 57.1 | 38.5 |
| Bio urine                 | 85.7 | 38.5 | 85.7 | 38.5 | 85.7 | 38.5 | 85.7 | 34.6 |
| Compost                   | 78.6 | 46.2 | 78.6 | 42.3 | 78.6 | 34.6 | 78.6 | 34.6 |

*CF=cooperator farmers
* NCF=noncooperator farmers

Confirmation level might be the actual adoption of technology because it has gone through an evaluation process reinforced by high knowledge and interest, also without any program intervention. At this level, it shows that farmers are applying the technology repeatedly, not just once. The percentage of cooperator farmers’ adoption of HYV technology and bio urine is still 85.7%, while young seedlings’ application decreased slightly to 78.6%. Likewise, the percentage of HYV technology adoption among noncooperator farmers is also constant (57.7%). It indicates that the technology characteristics are in accordance with farmers’ preferences, proofed by farmers continuing to apply this technology in the next planting season (technology adoption).

Technology characteristics are one of the determining factors for successful adoption. In conformity with [20,21,22], technological innovation characteristics have a positive and significant effect on technology adoption [10]. The use of young seedlings is still applied because it makes productivity increase. HYV has characteristics of resistance to pests and diseases, increases productivity, and grown better than existing varieties. In agreement with Syahri and Somantri [23], high-yielding rice varieties can suppress the attack of plant pests and contribute to increasing rice production. Likewise, the use of bio urine can increase rice growth and production by 11.2% compared to without bio urine [24].

Fertilization technology and the Jarwo planting system were the lowest technologies adopted by cooperator farmers, 35.7% and 42.9%, respectively. Fertilizer (30.8%), bio urine (34.6%), and compost...
technology (34.6%) were the lowest technologies adopted by noncooperator farmers. It is probably because the characteristics of the technology are not in accordance with farmers’ preferences. Serdang Bedagai farmers who no longer apply Jarwo stated it increases planting costs, while the additional benefits of the technology are not much perceived. Confirmed by research in Bangka Belitung, the Jarwo system requires additional costs and labor, making it difficult for farmers to adopt [19]. Another reason that noncooperator farmers’ low adoption of fertilization, bio urine, and compost technology is due to a lack of assistance.

3.3. SITT technology adoption period
Table 3 indicates that the average length of time required by farmers in Serdang Bedagai to determine the adoption of SITT technology is quite diverse. In general, most farmers required more than one planting season to adopt SITT technology (44.0%), 28.4% of farmers took one planting season, and the remaining (27.6%) needed less than one planting season. It indicates that farmers need concrete evidence regarding the superiority of technology so that farmers are certain to adopt it. In addition to the technology characteristics, the speed of adoption is influenced by the farmers’ characteristics, such as age, education, experience, farmer innovativeness, et cetera. Farmers still need continuous assistance from field extension workers, which is one of the keys to the successful adoption of technology.

Table 3. The time period of SITT technology adoption, Serdang Bedagai, North Sumatra, 2018.

| SITT technology components | < 1 season | 1 season | > 1 season |
|----------------------------|------------|----------|------------|
| HYV                        | 28.9%      | 21.1%    | 50.0%      |
| Fertilization              | 30.4%      | 30.4%    | 39.1%      |
| Young seedlings            | 31.3%      | 31.3%    | 37.5%      |
| Organic fertilizer         | 28.0%      | 36.0%    | 36.0%      |
| Jarwo                      | 24.0%      | 24.0%    | 52.0%      |
| IPM                        | 20.0%      | 33.3%    | 46.7%      |
| Bio urine                  | 25.0%      | 25.0%    | 50.0%      |
| Compost                    | 33.3%      | 25.9%    | 40.7%      |
| Average                    | 27.6%      | 28.4%    | 44.0%      |

3.4. Frequency of application of SITT technology
The frequency of farmers applying SITT technology by more than two planting seasons is evidence that the technology disseminated can provide benefits for farmers and is in accordance with farmers’ preferences. Table 4 shows that the average frequency of farmers who apply SITT technology more than two planting seasons reaches 66.0%, farmers who apply SITT technology for two planting seasons are 24.5%, and farmers who apply SITT technology only one planting season are 9.5%. The reasons that farmers are not applying SITT technology in the following planting season, among others, the technology is considered unable to increase profits, is not available in the field, is not in accordance with the farmers’ preferences and needs, and is even considered to increase costs and labor.

More specifically, HYV, compost, bio urine, and young seedlings are technologies that most farmers applied more than twice the planting season with percentages of 82.0%, 73.1, 70.4%, and 70.3%, respectively. These prove that those technologies can increase profits, fit the farmers’ needs, available in the field, and easy to implement. Other technologies, such as organic fertilizers, IPM, Jarwo, and fertilizers, are also applied by farmers more than twice the planting season, but with lower percentages, respectively 67.9%, 59.4%, 55.6%, and 50.0%. The reason is the application of these technologies (e.g., Jarwo) can result in additional labor, costs, and time, yet, it is still considered to provide profit.
Table 4. Frequency of application of SITT technology, Serdang Bedagai, North Sumatra, 2018.

| SITT technology components | Frequency of application of SITT technology (%) | 1 planting season | 2 planting seasons | > 2 planting seasons |
|----------------------------|-----------------------------------------------|-------------------|-------------------|---------------------|
| HYV                        |                                               | 0.0               | 18.0              | 82.0                |
| Fertilization              |                                               | 26.9              | 23.1              | 50.0                |
| Young seedlings            |                                               | 2.7               | 27.0              | 70.3                |
| Organic fertilizer         |                                               | 0.0               | 32.1              | 67.9                |
| Jarwo                      |                                               | 25.9              | 18.5              | 55.6                |
| IPM                        |                                               | 12.5              | 28.1              | 59.4                |
| Bio urine                  |                                               | 3.7               | 25.9              | 70.4                |
| Compost                    |                                               | 3.8               | 23.1              | 73.1                |
| Average                    |                                               | 9.5               | 24.5              | 66.0                |

4. Conclusions
The adoption of SITT technology for cooperator farmers was higher than that of noncooperator farmers, both the technology component and the level of adoption. The dominant components of SITT technology adopted by cooperator farmers are HYV, young seedlings, and bio urine, while the dominant technology adopted by noncooperator farmers is HYV. The average length of time required by farmers to adopt SITT technology is quite diverse; 44.0% of farmers need more than one planting season, 28.4% of farmers need one planting season, and 27.6% of farmers need less than one planting season. Furthermore, the frequency of farmers who apply SITT technology more than twice the planting season reaches 66.0%, while farmers who apply SITT technology only two planting seasons are 24.5%, and farmers who apply SITT technology only one planting season 9.5%.

For technology to be rapidly adopted, it must be technically, socially, and economically profitable. Therefore, to increase farmers’ adoption of technology, the technology should be suited to the farmers’ preferences and needs. In addition, the technology introduced should increase profits and ensure that the technology is available in the field. Another critical matter is providing continuous assistance during the introduction of technology.

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