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Research Article

# Comparison of External and Internal Inputs Usage Based on Enterprises Scale on Rice-cattle Integration Systems Farming

[1,2]Mukhlis, [3]Melinda Noer, [3]Nofialdi and [3]Mahdi

[1]Department of Food Crop Cultivation, Agricultural Polytechnic, Tanjung Pati, 26271 Harau, Lima Puluh Kota, West Sumatra, Indonesia
[2]Agricultural Sciences Study Program, Faculty of Agriculture, Andalas University, Padang, Indonesia
[3]Department of Socio-economic Agriculture, Faculty of Agriculture, Andalas University, Padang, Indonesia

## Abstract

**Background and Objectives:** The agricultural system that combines rice and cattle is characterized by a close relationship between input and output in terms of waste utilization. It also involves the use of low external input approach to creating environmentally friendly agriculture with the ability to increase production, productivity and farmers' income. However, the external and internal inputs used on RCIS farming based on the concept of Low External Input Sustainable Agriculture have never been compared. Therefore, this study focused on comparing the use of external and internal inputs in RCIS farming. **Materials and Methods:** This study use descriptive method. Collection of primary data by interviews, documentation and observations. The data were tabulated, analyzed and explained both qualitatively and quantitatively. **Results:** Production of cattle feces was found to be 8-15 kg/head/day. Small-scale farmers were observed to use manure, medium and large-scale use manure and compost fertilizer. Rice straw production was 8-13 t ha$^{-1}$/planting season and small-scale farmers used fresh straw, medium-scale and large-scale used fermented straw. Furthermore, lack of hay for cattle feed was 61.78% for small-scale, medium-scale 75.23% and large-scale 54.53%. **Conclusion:** The greater of scale enterprises, the lower the use of internal inputs and the greater the use of external inputs and also lowers the integration characteristics because it is not environment friendly. The use of external inputs on small-scale RCIS farming was very small so that very integrative because it uses more self-owned and environmentally friendly local internal inputs.

Key words: Comparison, external and internal input, Integration, RCIS farming, waste utilization

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Corresponding Author: Mukhlis, Department of Food Crop Cultivation, Agricultural Polytechnic, Tanjung Pati, 26271 Harau, Lima Puluh Kota, West Sumatra, Indonesia



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Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Agricultural development is a process of change in a better direction in the agricultural sector[1]. Furthermore, sustainable development focuses on meeting the needs of the present generation without sacrificing what is needed by future to meet their own[2,3]. Therefore, sustainable farming systems are implemented through 4 models which include organic, integrated, low external input and integrated pest control farming systems[4].

Integrated farming (IFS) is an agricultural system that combines two or more fields of agriculture[5-10] by using the concept of biological recycling with an input-output relationship between the commodities[8,11-13] and application of low external input[14-17] and resources[18-20]. Furthermore, several techniques are being applied to increase production, productivity, farmer income and sustainability[13,21-22].

Therefore, IFS is an agricultural system that uses the concept of biological recycling between plants and livestock in an input and output relationship, with maximum usage of 25% low external input in order to reduce the use of inorganic fertilizers and increase farmers' income. This approach is based on the results of Wardhie *et al.*[23] which suggests the use of external inputs such as inorganic fertilizers, lime and pesticides in sustainable farming to be 11-25% while internal inputs such as organic fertilizer and manure should be 75-89%. However, one model of this is the rice-cattle integration system (RCIS) farming.

The RCIS is a farming system that integrates rice and cattle in a reciprocal relationship. Rice plants provide straw and bran for cattle as feed while the cattle produce feces as organic fertilizer for the rice plants. This is targeted towards increasing the production and productivity of rice and cattle and, consequently, an increase in farmers' income[24]. The system is said to combine rice and cattle in a close relationship between input-output in terms of waste utilization through the use of Low External Input Sustainable Agriculture (LEISA) approach to create environmentally friendly agriculture and to also increase production, productivity and farmers' income.

The LEISA model, however, involves optimizing the use of local resources by combining various components of integrated farming systems such as plants, livestock, fish, land, water, climate and humans to complement and provide the greatest synergy effect. The use of low external inputs is only needed to supplement the elements lacking in the agroecosystems and to also increase biological, physical and human resources. The aim of this model therefore is not to maximize productivity in the short term, but to achieve a stable and adequate level of production in the long run[25].

The scale of business is the size of the land cultivated by a farmer which greatly determines the level of production and income to be obtained[26]. It must, however, be considered by farmers because it is very decisive in achieving maximum business profits[27,28]. The scale of enterprises is expected to be useful in the development of RCIS farming from the economic, socio-cultural, environmental and technical aspects. Furthermore, Sajogyo[29] grouped farmers in Java into 3 categories and they include small-scale with farmland area <0.5 ha, medium scale with farmland area 0.5-1.0 ha and wide-scale farmland area. About >1, 0 ha while the beef cattle business was categorized into small scale with 1-5 cows, medium scale 6-10 cows and large-scale >10 cows[30,31].

Therefore, the research problem is to compare the usage of the external and internal input on RCIS farming based on the concept of Low External Input Sustainable Agriculture and the purpose was to compare external and internal inputs usage on RCIS farming.

## MATERIALS AND METHODS

The descriptive approach was used to describe and summarize several conditions, situations and variables. Furthermore, a survey was conducted on large and small populations to obtain data on the events, distribution and relationships between variables[32].

This study was conducted in Lima Puluh Kota Regency and through the use of a purposive method, 3 sub-districts were chosen, Payakumbuh, Guguak and Harau based on the conditions that they are centers of integrated rice production in the District and unavailability of such research in the area. The study was conducted for 3 months, from May to July, 2018.

The samples were determined by using a snowball sampling method because of the unavailability of population number data needed to create a sample frame. The first stage of the method involved getting respondents who fit the criteria set, followed by the appointment or invitation of other friends until the number of samples needed to answer the research objectives is attained. Therefore, the number of samples could not be determined at the start of the study by Rianse and Abdi[33] and Lyons and Doueck[34]. The Snowball sampling technique is used when researchers have difficulty finding or identifying populations and appropriate number to be used[35-37].

Figure 1 shows the snowball sampling technique, it involves the gathering of samples through a rolling process from one respondent to another[38].

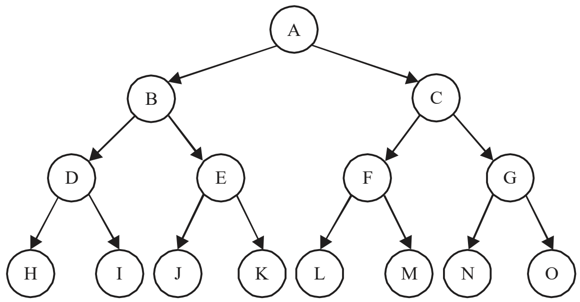


Fig. 1: Chart of snowball sampling techniques

The farmers' samples were made up of those raising cattle either personal or investors owned and those cultivating rice, personal or investors owned and pawns. They all made up of 100 respondents used as samples in this study. Furthermore, the unit of analysis was the RCIS farming family of farmers and farmers in groups.

Both primary and secondary data were collected. Primary data were derived from information obtained on rice seeds, manure, compost, inorganic fertilizers, pesticides, forage, straw and concentrate feeds, worm, lice and wound medicines, vitamins, bran, oil palm cake, cassava, minerals, Trichoderma, lime, sawdust and husk ash and the price of each input directly from the respondent through interviews, observation and documentation conducted in the 3 sub-districts. While secondary data originated from relevant institutions and agencies, such as the Central Statistics Agency, Profile of Nagari and other relevant scientific works.

The basic method employed in this research was descriptive analysis. It involves solving problems in a systematic way from the data obtained, collected, compiled, tabulated, analyzed and explained both qualitatively and quantitatively. For the purpose of this study, the following steps were used:

- Collect and tabulate all data on the amount and price of all inputs
- Calculate the cost of each input by multiplying them with their respective prices. This is mathematically written as follows:

$$\text{Input cost (IC)} = X \times Px$$

Calculate the total cost of production inputs, using:

$$ITC = EIC + IIC$$

Calculate the percentage of the usage of the external and internal input, using:

$$\text{Percentage} = \frac{IC}{ITC} \times 100$$

Where:

X = Number of inputs (Unit)
Px = Price of input (IDR/unit)
ITC = Input total cost (IDR)
EIC = External Input cost (IDR)
IIC = Internal input cost (IDR)

Describe the analyzed result qualitatively and quantitatively.

## RESULTS AND DISCUSSION

The agricultural system with low external input involves minimizing the excessive use of external inputs such as superior seeds, chemical fertilizers and pesticides on the ecosystem. Furthermore, sustainable agriculture systems using LEISA approach require efficient allocation of local resources with minimal reliance on expensive external inputs which are dangerous for both human and the environment[25].

Table 1 shows the larger scale of an enterprise to have greater use of external inputs. This is evidenced from the results that the use of external inputs on small-scale to be only 8.61%, medium-scale 46.09% and large-scale was higher with 77.12% while the internal inputs were 91.39, 53.91 and 22.88%. Figure 2-4 shows input in a graphical form for more clarity.

Figure 2 shows the percentage of external inputs used on small-scale RCIS farming was very small at 8.61% because farmers have not processed cattle feces into organic fertilizer and have not treated straws as cattle feed. Therefore, the inputs used consisted of inorganic fertilizers at 5.14%, pesticide 1.17%, concentrate feed 2.12% and drugs at only 0.18%. However, on the overall, the straw needed as cattle feed could be obtained by harvesting rice wastes from the field. It can, therefore, be concluded that small-scale RCIS farming is very integrative because it uses more self-owned and environmentally friendly local internal inputs.

Figure 3 shows the percentage of external input used in medium-scale RCIS farming to be higher at 46.09%. This could be associated with the processing of cow feces into compost for rice plants and has fermented straw to feed cattle requiring additional ingredients. Therefore, the inputs used include inorganic fertilizers at 3.06%, pesticide 0.49%, feed concentrate 19.76%, medicines 0.22%, shortage of hay for 17.39%, additional material to process feces into compost was 4.17% and for straw into cattle feed was 1.08%. However, the

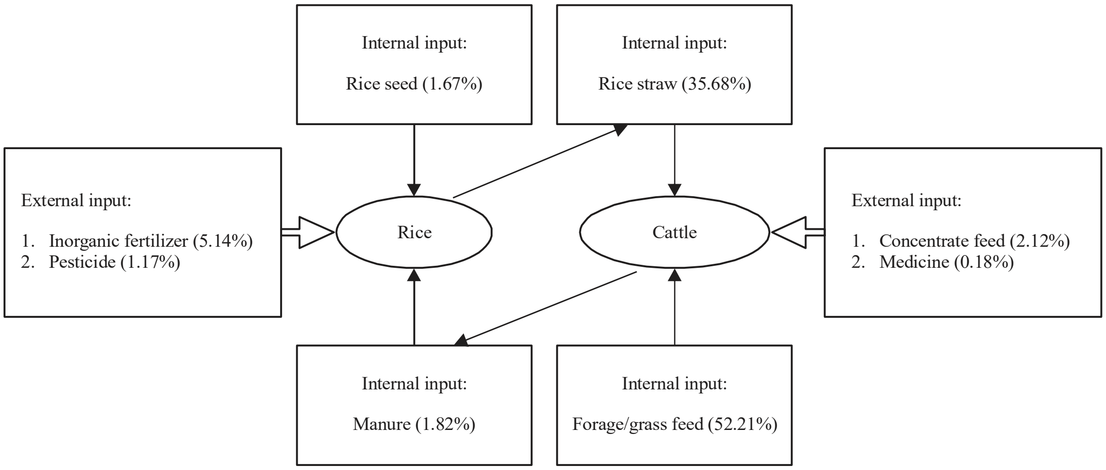


Fig. 2: Percentage of external and internal inputs use on a small scale

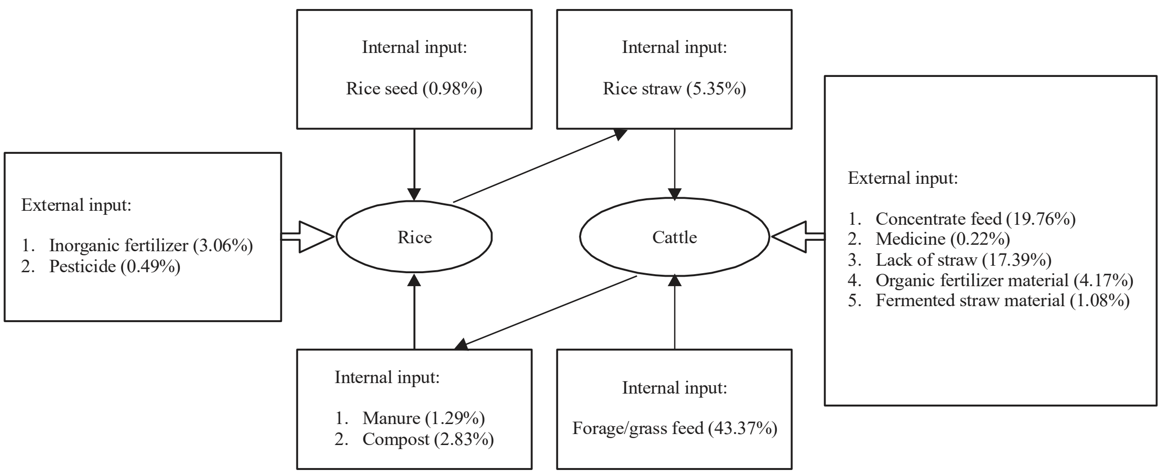


Fig. 3: Percentage of external and internal inputs use on a medium scale

total hays needed to feed the cattle cannot be met only by the harvested paddy waste. It can, therefore, be concluded that medium-scale RCIS farming is less integrative because it uses more external inputs.

Figure 4 shows the percentage of external inputs used on a large-scale RCIS farming to be very high at 77.12%. This was because farmers have processed cattle feces into compost for rice plants and have fermented straw to feed cattle requiring additional ingredients. Therefore, more external inputs were used and they include inorganic fertilizers at 4.09%, pesticide 3.06%, feed concentrate 27.66%, medicines 0.33%, lack of straw feed was 12.83%; additional material to process feces into compost was 5.14% and for straw into cattle feed was 22.15%. However, the total hays needed to feed the cattle cannot be met only by the harvested paddy waste. It can, therefore, be concluded that large-scale RCIS farming is less integrative because it uses more external inputs. Furthermore, many farmers used cow feces as manure and compost for rice while fresh and fermented straws were used as cattle feeds.

Figure 5 shows the use manure and compost fertilizer. RCIS farmers, in general used cow feces as organic fertilizer both as manure and compost, however, some of them also used other manures. The results showed the cattle feces produced was 8-15 kg/head/day with small-scale RCIS farmers using 100% manure, medium-scale 86.67% with 13.33% compost fertilizer and large-scale 66.67% with 33.33% compost. However, the average feces produced was small-scale 11.97 kg/head/day, medium-scale 12.13 kg/head/day and large-scale 17.88 kg/head/day.

From the study results it was found that a cattle of both small-scale RCIS, medium-scale and large-scale was able to produce feces about 8-15 kg/head/day. However, the average feces produced, namely: Small-scale 11.97 kg/head/day, medium-scale 12.13 kg/head/day and large-scale 17.88 kg/head/day.

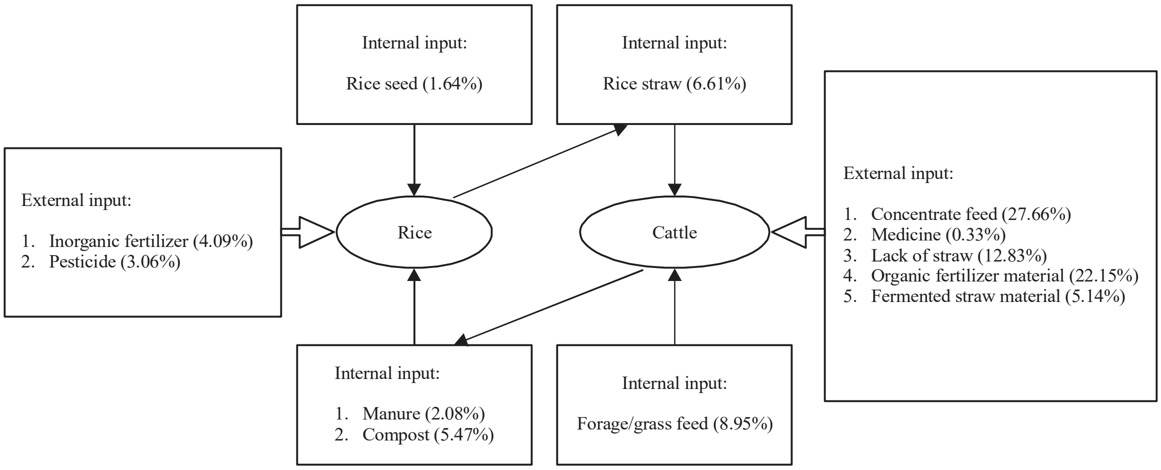


Fig. 4: Percentage of external and internal inputs used on a large scale

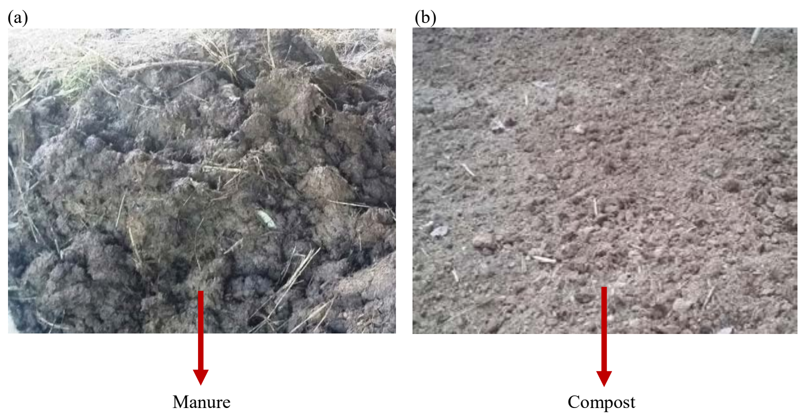


Fig. 5(a-b): (a) Manure and (b) Compost fertilizer on RCIS farming

Table 1: Use of external inputs and internal inputs on RCIS farming

| Production input | Small scale | | Middle scale | | Large scale | |
|---|---|---|---|---|---|---|
| | Cost (IDR 000) | Percentage | Cost (IDR 000) | Percentage | Cost (IDR 000) | Percentage |
| **A. Internal inputs** | | | | | | |
| **1. Rice plants** | | | | | | |
| a. Rice Seed | 294.32 | 1.67 | 623.38 | 0.98 | 3,504.13 | 1.51 |
| b. Manure | 321.37 | 1.82 | 819.23 | 1.29 | 4,455.00 | 1.93 |
| c. Compost | | | 1,800.00 | 2.83 | 11,700.00 | 5.06 |
| **2. Cattle** | | | | | | |
| a. Forage/grass feed | 9,209.18 | 52.21 | 27,606.00 | 43.44 | 19,147.50 | 8.28 |
| b. Straw feed | 6,293.84 | 35.68 | 3,405.18 | 5.36 | 14,140.00 | 6.11 |
| Total IIC | 16,118.71 | 91.39 | 34,253.79 | 53.91 | 52,946.63 | 22.88 |
| **B. External inputs** | | | | | | |
| **1. Rice plants** | | | | | | |
| a. Inorganic fertilizer | 906.80 | 5.14 | 1,949.50 | 3.07 | 8,753.75 | 3.78 |
| b. Pesticide | 206.66 | 1.17 | 5,502.11 | 0.49 | 6,546.00 | 2.83 |
| **2. Cattle** | | | | | | |
| a. Feed concentrate | 373.95 | 2.12 | 12,513.54 | 19.69 | 76,579.79 | 33.10 |
| b. Drugs | 31.92 | 0.18 | 103.97 | 0.16 | 696.23 | 0.30 |
| c. Compost material | | | 2,652.97 | 4.17 | 11,004.91 | 4.76 |
| d. Lack of straw | | | 11,070.62 | 17.42 | 27,452.50 | 11.87 |
| e. Fermented straw material | | | 690.34 | 1.09 | 47,387.53 | 20.48 |
| Total EIC | 1,519.33 | 8.61 | 34,483.05 | 46.09 | 178,420.71 | 77.12 |
| ITC | 17,638.04 | 100.00 | 68,736.84 | 100.00 | 231,367.34 | 100.00 |

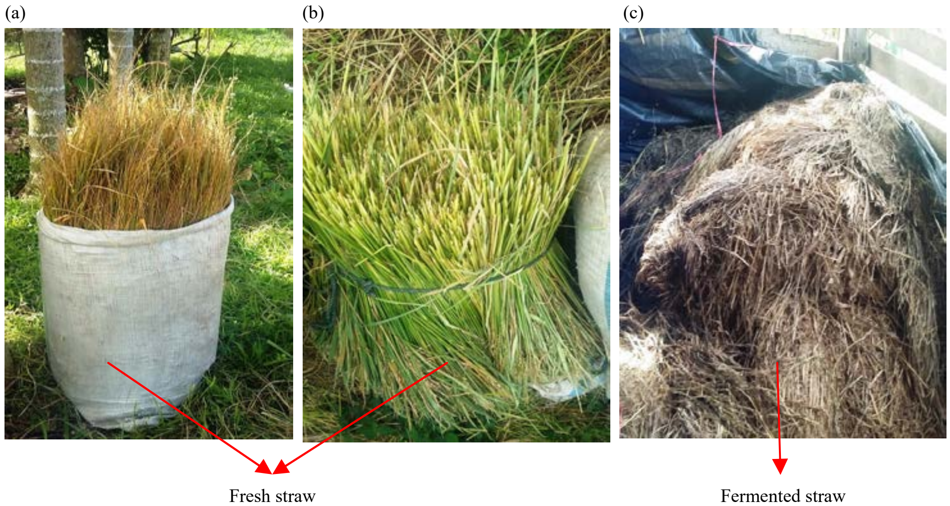


Fig. 6(a-c): Feed of (a-b) Fresh and (c) Fermented straws on RCIS farming

These results revealed the feces produced by cattle were enough for the manures needed by the farmers. However, some of them have not used manure according to the recommended dosage of 2 t ha$^{-1}$. Small-scale farmers were found to have 87.24% compliance, medium-scale 91.48% equivalent to 1.83 t ha$^{-1}$ and large-scale 100% as shown in Table 2.

Table 2 shows the potential of manure production from RCIS farming on all three business scales to be very high. The small scale was found to be 9,795.86 kg/season, medium 28,266.23 kg/season and large 191,677.50 kg/season. However, rice plants require very small quantity with small scale at 1,711.64 kg/planting season, medium 4,038.46 kg/planting season and large 22,500.00 kg/planting season.

It was also discovered that the total composts needed by farmers were produced by from the cattle's feces. However, some were found not to be applying the compost with the recommended dosage of 1 t ha$^{-1}$. Those running small-scale RCIS farms did not use compost fertilizer, medium with 90.00% compliance and large-scale with 100%. The detail information is shown in Table 3.

Table 3 shows the potential of compost fertilizer production from RCIS farming on the medium and large scale to be very high with 31,185.00 kg/season and 104,623.50 kg/season, respectively. However, the rice plants' need for compost was very small with a medium scale requiring 1,950.00 kg/planting season and a large scale of 14,625.00 kg/planting season.

The cattle feed is a combination of fresh straw and forage or grass with concentrates obtained by grazing on free land. However, 20-40 kg/head/day of forage is needed by cattle according to the standard requirements. In research conducted by Ilham[39], between 31.44-62.56 kg/head/day is required for livestock. The quantity needed could be obtained personally by the farmers or through the payment of Rp 10,000-15,000/sack, which is equivalent to IDR 250/kg to IDR 300/kg to other people. Furthermore, forage feeds were obtained from rice fields or gardens owned by the farmers themselves or those of the surrounding community.

Figure 6 shows the feed of fresh and fermented straws. The utilization of rice straw waste as cattle feed was conducted by all the RCIS farmers. The fresh straw needed for cattle is 20-40 kg/day or an average of 25 kg/day if combined with forage. Most of the feed were sourced from the owned rice fields while the rest were purchased from other farmers with excess. The straw feed in small-scale farming was different from the others because they were fermented with the addition of 2-3 kg t$^{-1}$ Urea and Starbio to increase the nutrition of the feed.

According to farmers, the fresh straw feed must be added with fresh forage and other commercial feeds, because of its low nutritional value, ability to only satiate and very little benefit to weight gain. However, fresh straw feed is very good for compost making because it aids the production of more feces.

Rice straw production was 8-13 t ha$^{-1}$/planting seasons and small-scale RCIS farmers used 100% fresh straw as cattle feed, medium used 86.67 and 13.33% fermented straw, while large used 16.67 and 83.33% fermented. Furthermore, lack of hay for cattle feed was 61.78% for small-scale, medium-scale 75.23% and large-scale 54.53%.

Table 2: Production and requirement of manure in RCIS farming

| Description | Small scale | Middle scale | Large scale |
|---|---|---|---|
| 1. Production of cattle feces (kg/head/day) | 11.97 | 12.13 | 17.88 |
| 2. Production of manure (kg/season) | 9,795.86 | 28,266.23 | 191,677.50 |
| 3. Need for manure (kg/season) | 1,711.64 | 4,038.46 | 22,500.00 |
| 4. Use of manure (%) | 19.68 | 15.23 | 27.95 |
| 5. Excess manure (kg) | 8,084.22 | 24,227.77 | 70,981.88 |
| 6. Excess manure (%) | 80.32 | 84.77 | 72.05 |
| 7. Application of manure according to the recommended dosage of kg ha$^{-1}$ (%) | 87.24 | 91.48 | 100.00 |

Table 3: Production and requirement of compost fertilizer for RCIS farming

| Description | Small scale | Middle scale | Large scale |
|---|---|---|---|
| 1. Production of cattle feces (kg/head/day) | - | 12.13 | 17.88 |
| 2. Production of compost (kg/season) | - | 31,185.00 | 104,623.50 |
| 3. Need for compost (kg/season) | - | 1,950.00 | 14,625.00 |
| 4. Use of compost | - | 6.69 | 17.03 |
| 5. Excess compost (kg) | - | 29,235.00 | 89,998.50 |
| 6. Excess compost (%) | - | 93.31 | 82.97 |
| 7. Application of compost according to the recommended dosage of kg ha$^{-1}$ (%) | - | 90.00 | 100.00 |

Table 4: Production and need of rice straw for cattle feed

| Description | Small scale | Middle scale | Large scale |
|---|---|---|---|
| 1. Need for rice straw (kg) | 32.095,89 | 123,092,0 | 39,400.00 |
| 2. Production of straw (kg/bundle) | 10,00 | 12,77 | 10,00 |
| 3. Straw production (kg/sack) | 36,67 | 0 | 40,00 |
| 4. Straw production (kg) | 10.353,45 | 26,946,00 | 190.042,50 |
| 5. Conversion to hectare | 10.114,05 | 11,742,92 | 10.595,50 |
| 6. Lack of straw (kg) | 21.780,25 | 96.146,31 | 249.733,33 |
| 7. Used straw (%) | 38,22 | 11,65 | 45,47 |
| 8. Excess straw (%) | 0,71 | 0 | 39,65 |
| 9. Straw deficiency (%) | 68,33 | 88,35 | 72,71 |
| 10. Additional land area to meet straw (ha) | 1,39 | 6,29 | 7,69 |

However, the total straws produced, both fresh and fermented; do not have the ability to meet the requirements of the cattle. It was discovered that only 5.48% was met for small scale, 27.03 for medium and 45.47% for large scale.

The production of rice straw on small and medium scales RCIS farming was found to be 8-12 t ha$^{-1}$/planting season with 8-13 t ha$^{-1}$/planting season for large scale. This shows straw production to be quite high in accordance with the results of some previous studies. One hectare of rice fields has the ability to produce 10-12 t of straw[40-41]. The comparison of yields of rice to straw (grain straw ratio) was generally 2:3, therefore, the straw produced from one hectare of the rice field is usually 5-8 t depending on the varieties planted and the level of soil fertility[42]. Another research showed each hectare of rice fields to produce around 8-12 t of straw (1.5 times the grain yield) per season or equivalent to 4-6 t of straw compost/hectare/season[43]. Furthermore, other researchers reported straw produced in rice cultivation to be 7-10 t ha$^{-1}$/planting season[44,45]. However, the straw needed for cattle feed was generally not fulfilled with 68.33% for small scale, 88.35% for medium and 72.71% for large scale as shown in Table 4.

The straw needed to feed cattle and rice straw production for 3 seasons for small scale was 9.6-72 t and only 2.7-18 t and medium-scale 9.6-72 t and only 2.7-18 t, respectively. However, the straws have the ability to satisfy only 38.22% with 61.78% unattended. The fresh straw needed in medium-scale SIPT was 64.8-192 t, while rice straw production for 3 seasons was only 26.95 t. This shows that the straws have the ability to satisfy only 24.77% leaving 76.97 t.

Furthermore, the rice straw for cattle feed in large-scale RCIS reached 192-280.80 t of fresh and 76.80-693 t of fermented, while rice straw production for 3 seasons was only 190,042.50 t. This shows that the straws have the ability to satisfy only 45.47% leaving 249.73 t.

## CONCLUSION

The uses of internal and external inputs have difference between each scale enterprises in RCIS farming. The greater of scale enterprises lower the use of internal inputs. The greater scale leads to higher use of external inputs and also lowers the integration characteristics of RCIS farming because it is not environment friendly.

The use of external inputs on small-scale RCIS farming was very small because farmers have not processed cattle feces into organic fertilizer and have not treated straws as cattle feed. Therefore, Small-scale RCIS farming is very integrative because it uses more self-owned and environmentally friendly local internal inputs.

## SIGNIFICANCE STATEMENT

This study addresses the comparison of using external and internal inputs in RCIS farming. This is important to understanding that scale enterprises is an important factor in RCIS farming related to the use of both external and internal inputs. Different business scales will cause different uses of internal and external inputs and also different ways of RCIS farming. The greater the scale of the RCIS farming business, the less integrative it is because the more use of chemicals that are not environmentally friendly and the greater the additional costs of buying external inputs.

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