The impact of technological innovation of Jajar Legowo 2: 1 planting system on rice business income

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Abstract. One of the technological components in rice cultivation is jajar legowo (Jarwo) planting system. The study aimed to determine the impact of the application of Jarwo planting system on rice farming income and reveal the technical and socio-economic factors that might affect the performance of jarwo application in lowland rice farming. The study was conducted in Pinrang Regency area in 2017. Farmer's characteristic data were collected, and the economic farming was analyzed by either the tegel or the Jarwo planting system. The results showed that the jarwo planting system increases the paddy production up to 33.07% than the tegel system. Moreover, the production cost of Jarwo planting system slightly lower than the tegel system. The R / C value of tegel and Jarwo planting system obtained were 1.21 and 1.87, respectively.

In conclusion, the Jarwo planting system has had a beneficial impact on farmers.

1. Introduction

The jajar legowo (Jarwo) planting system is one of rice cultivation's technological components, optimizing rice productivity through population regulation. By planting Jarwo 2:1, the plant population reached 213,000 clumps/ha. In comparison, the tegel system (25 x 25 cm) produced 160,000 clumps/ha, meaning that the Jarwo planting system increased the plant population by 33.3% compared to tegel system. The increase in plant populations was due to the way Jarwo was planted. All rows of plants received secondary plants. Increased rice plant productivity in the Jarwo planting system also occurs because the plant growing space is vast to maximize sunlight. In addition, weeding, fertilizer application, pest and disease control are also more effective \[1,2\].

The application of the Jarwo planting system has more impact in the rainy season due to the low intensity of the sun \[3,4\]. Without Jarwo, the use of N fertilizer by plants would be ineffective because the number of tillers formed in these conditions would be lower.

Meanwhile, the presence of a more expansive planting space at Jarwo increases photosynthetic activity, which impacts increasing productivity, making it easier for farmers to carry out additional fertilization, weeding, pest, and disease control \[5\]. This Jarwo planting system also provides an opportunity to raise fish among the rice plants and the rice-fish-duck combination. Thus, rice farmers, apart from having a source of income from rice, also earn income from fish and ducks.

The Jarwo planting system 2: 1 can reduce vacuum due to the effects of marginal crops \[6\]. The literature showed that the Jarwo planting system 2: 1 with a spacing (25 x 12.5 x 50) cm increased the yield higher between 9.63-15.44% compared to the tegel planting method \[7,8\].
The impact of the width of the spacing on Jarwo was also proven to reduce the attacks of leaf smut and sheath blight [9]. It was also reported that the stem borer population was not significantly different in using the 2:1 Jarwo and tegel planting system [10,11]. The Jarwo planting system creates the microclimate conditions under the plant canopy that become unsuitable for pathogens development. This condition is also confirmed that farmers who apply the Jarwo method find it easy to weed, fertilize and maintain plants [12]. However, the installation of Jarwo still faces obstacles. Many farmers are not sure of the superiority of the legowo planting system technology, lack of capital, limited agricultural machinery, and lack of detailed information for the Legowo planting system [13].

The study aims to determine the impact of the application of Jarwo cultivation on rice farming income and reveal the technical and socio-economic factors predicted to affect the performance of jarwo application in lowland rice farming.

2. Methods
The study was conducted in South Sulawesi Province, focusing on the Pinrang Regency area in mid-2017. The data collection method was carried out through interviews with 30 farmers selected as simple random respondents. All of these respondents applied the Jarwo planting method in rice farming. The variety planted is Ciherang, following the preferences of farmers in that area who like the Ciherang variety.

Primary data were collected, namely farming input which includes expenses for purchasing production facilities (seeds, fertilizers, and pesticides), expenses for purchasing agricultural business infrastructure (hoes, sickles, hand sprayer, boots), wages, taxes. In addition, data on productivity achievement and the price of grain were also collected.

Data analysis to determine the impact of applying the Jarwo planting method was carried out through the before-after and with-without comparative approaches, in each of the initial conditions (before) and conditions after (after), as well as for the conditions that applied Jarwo (with) and those that did not apply Jarwo (without), a partial budgeting analysis was carried out, with success indicators measured from the R/C and B/C parameter. Furthermore, to determine the impact of implementing the Jarwo planting method, the analysis was carried out using the Losses and Gain approach [14]. From this analysis, the measure assessed is the Marginal Benefit-Cost Ratio (MBCR).

To obtain R/C and B/C information, the analysis is carried out based on the financing structure and farm income. The rule for decisions taken is R/C > 2.8 and B/C > 1.8. The R/C and B/C values are determined by including the 80% risk element [14]. Meanwhile, the reference value for MBCR used is MBCR > 2. This means that each output of one unit of sacrifice produces an output of two units.

Comparisons were made of net income on variable costs (return above variable cost = RAVC), the marginal benefit-cost ratio (MBCR), and the rate of returns to scarce factors of production, with the following formula:

\[ \text{RAVC} = \frac{(Y \times P)}{\text{TVC}} \]

\[ Y = \text{plant productivity (kg / ha or kg)}; \]
\[ P = \text{selling price of plant products (IDR / kg)}; \]
\[ \text{TVC} = \text{total variable costs (IDR / ha)}. \]

\[ \text{MBCR} = \frac{\text{Revenue (J)} - \text{Revenue (P)}}{\text{Total cost (J)} - \text{Total cost (P)}} \]

In this case, J = jarwo technology; and P = farmer technology

Theoretically, the decision is made: MBCR technology BPTP must value > 1 to attract farmers to adopt the technology. If the MBCR < 1, it means that the BPTP technology has no financial potential. MBCR = 1 means that the additional revenue received equals the additional costs incurred due to adopting the new technology, so that there is no incentive to adopt [15].
A SWOT approach was carried out to reveal the factors predicted to affect the performance of the application of the Jarwo planting method [14]. With a SWOT analysis, an overview of the potential, opportunities, challenges, and threats of applying the Jarwo planting method to rice farming will be obtained.

3. Results and discussion

3.1. Respondent characteristics
The characteristics of the respondents revealed in this study include age, formal primary education, land tenure for farming, and side jobs. The characteristics of these respondents are considered to underlie the farmers' decision to accept or not to accept the introduction of the innovation.

3.1.1. Age. The age range of respondents was between 35 and 75 years, with an average age of 55 years. At the same time, the age factor shows a relationship with farming experience, although the relationship is not always linear. This means that farmers with relatively old age do not always indicate that the farmers have the highest experience. In essence, the majority of farmers selected as respondents are in the productive criteria. Thus, it is predicted that the Jarwo planting method innovation intervention will be well appreciated at the study site.

3.1.2. Formal education. Formal education is important because the basis of education is related to the capacity and capability of a person, which is usually reflected in his attitudes and actions. Thus, education level is one of the main factors that affect technology adoption [16]. Based on the results of interviews in the field, it is known that respondents have various bases of formal education, ranging from respondents who did not attend school, graduated from elementary school, graduated from junior high school, and graduated from high school.

The majority of respondents in the study locations (50 percent) are at the primary school level. Respondents with the highest education (SLA) are around 17 percent, and none of the farmers have completed education at the tertiary level. However, besides that, some farmers do not have the opportunity to attend formal education, even though the numbers are relatively small. With the respondent's formal education base composition, the chances of adopting innovation in the Jarwo planting method will be relatively high.

3.1.3. Land tenure. Land tenure by farmers in the study location is generally differentiated into the land they own, lease, and hold. However, the status of all respondents in the study locations was classified as land owned by the farmers themselves. There are no respondent farmers who rent or use rice fields in carrying out their farming. The average area of arable land is 0.25 hectares, to be precise 25.57 acres.

The average of 0.25 ha of land owned by the respondents is relatively small to obtain adequate farming income. The results of farming in such an area are only sufficient to meet household needs. Therefore, management is needed to optimize the narrow land, and then the farmers continue to exist.

3.1.4. Side job. Apart from working as farmers, farmers generally have jobs outside of rice farming. The types of side jobs that are done are pretty diverse. However, in the study location, there were about 40 respondents who did not have side jobs. The rest, some respondents, work as breeders, construction workers, blacksmiths, mechanics, and laborers. This condition reflects that rice farming is still the main job.

3.2. Farming business cost structure
Respondents at the study site generally cultivated Cihelang rice plants by planting the 2:1 Jarwo pattern. In one year, they plant twice, namely the rainy season and the dry season. The analysis conducted is limited to rice farming in one season, namely in the rainy season.
The elements of financing for rice farming at the study site include financing for the purchase of rice seeds, pesticides, working wages, and financing for expenses that are not directly related technically to rice farming, including financing for group contributions, payment of land, and building tax social.

The total costs incurred for the payment of input elements for a farming business covering an area of 0.25 hectares averaged around IDR 3.9 million. The majority of the allocation is intended to provide variable costs and fixed costs with a proportion of IDR 3.5 million and IDR 0.4 million, respectively.

For labor costs, respondents use piece labor and family labor. The amount of labor costs in the family is measured using the person working day (HOK). The average domestic labor cost was IDR 2.3 million, and the average out-of-household labor cost per hectare was IDR 8.1 million.

Fixed costs incurred were IDR 1.5 million, while non-fixed costs were IDR 13.9 million. So the total production cost per hectare is around IDR 15.5 million (see table 1).

### Table 1. Ciherang variety of rice farming business financing structure, 1 ha in one planting season at the study site, 2017.

| No | Description            | Planting System | Difference (4-3) | Percentage (%) |
|----|------------------------|-----------------|------------------|----------------|
| 1  | Rice seeds             | Tegel (IDR)     | 363,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 363,000.00       | -              |
| 2  | Fertilizer:            |                 |                  |                |
|    | -Urea                  | Tegel (IDR)     | 600,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 600,000.00       | -              |
|    | -TSP                   | Tegel (IDR)     | 480,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 480,000.00       | -              |
|    | -NPK Phonska           | Tegel (IDR)     | 548,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 548,000.00       | -              |
|    | -ZA                    | Tegel (IDR)     | 410,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 410,000.00       | -              |
|    | -Petroganik            | Tegel (IDR)     | 51,000.00        | -              |
|    |                        | Jarwo 2:1 (IDR) | 51,000.00        | -              |
| 3  | Pesticide              | Tegel (IDR)     | 117,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 117,000.00       | -              |
| 4  | Labor cost             | Tegel (IDR)     | -                |                |
|    | -Tillage               | Tegel (IDR)     | 2,450,000.00     | -              |
|    |                        | Jarwo 2:1 (IDR) | 2,450,000.00     | -              |
|    | -Seedling              | Tegel (IDR)     | 145,100.00       | 15,900.00      |
|    |                        | Jarwo 2:1 (IDR) | 141,200.00       | 19.66          |
|    | -Planting              | Tegel (IDR)     | 1,471,000.00     | 220,000.00     |
|    |                        | Jarwo 2:1 (IDR) | 1,691,000.00     | 14.96          |
|    | -Base fertilizing      | Tegel (IDR)     | 207,000.00       | 15,000.00      |
|    |                        | Jarwo 2:1 (IDR) | 222,000.00       | -9.66          |
|    | -Fertilizing 1         | Tegel (IDR)     | 144,000.00       | 30,000.00      |
|    |                        | Jarwo 2:1 (IDR) | 174,000.00       | 20.83          |
|    | -Fertilizing 2         | Tegel (IDR)     | 144,000.00       | 30,000.00      |
|    |                        | Jarwo 2:1 (IDR) | 174,000.00       | 20.83          |
|    | -Weeding               | Tegel (IDR)     | 1,367,000.00     | -200,000.00    |
|    |                        | Jarwo 2:1 (IDR) | 1,167,000.00     | -14.63         |
|    | -Spraying              | Tegel (IDR)     | 148,000.00       | -1,000.00      |
|    |                        | Jarwo 2:1 (IDR) | 138,000.00       | -6.76          |
|    | -Irrigation            | Tegel (IDR)     | 181,000.00       | -10,000.00     |
|    |                        | Jarwo 2:1 (IDR) | 171,000.00       | -5.52          |
|    | -Harvesting            | Tegel (IDR)     | 4,510,000.00     | -509,000.00    |
|    |                        | Jarwo 2:1 (IDR) | 4,001,000.00     | -11.29         |
| 5  | Purchase of equipment  | Tegel (IDR)     | 73,000.00        | -              |
|    |                        | Jarwo 2:1 (IDR) | 73,000.00        | -              |
| 6  | Taxes payment          | Tegel (IDR)     | 200,000.00       | -              |
|    |                        | Jarwo 2:1 (IDR) | 200,000.00       | -              |
| 7  | Social expenses        | Tegel (IDR)     | 1,200,000.00     | -              |
|    |                        | Jarwo 2:1 (IDR) | 1,200,000.00     | -              |
|    | Total                  | Tegel (IDR)     | 14,809,100.00    | -453,100.00    |
|    |                        | Jarwo 2:1 (IDR) | 14,356,000.00    | -3.06          |

3.2.1. Farm revenue and income. Revenue refers to the achievement of rice production times the price, while farm business income is the value of revenue minus all the financing that has been issued. Rationally, production is related to the number of clumps that produce grain. The more the plant population, the more grain production will be obtained.
The results of interviews in the field also show that farmers who practiced the Jarwo planting method in plain view obtained relatively higher production than rice production from rice fields that applied the tegel system, namely 6708 kg gkp / ha compared to 4489 kg gkp / ha. There is a difference of 2219 kg / ha or around 33.07 %. Jarwo planting system 2:1 has been proved to give the higher production, followed by Jarwo 4:1 complete planting system [17]. Similarly, the Jarwo planting system showed better performance, either the yield or the production cost, than the conventional planting system [18].

Assuming all production is sold at the level of unhusked rice in effect at the time of the survey, which reached IDR 4000 per kg, the farmer who applies the Jarwo planting method will receive IDR 26,832,000. Meanwhile, farmers using the tegel system received IDR 17,956,000. Thus, from one hectare of rice plants, there is a difference in revenue of IDR 8,876,000.

After calculating the total financing, an illustration of farmers' rice farming's income level through the tegel planting system is IDR 3,146,900 and farmers who plant paddy using the Jarwo method receive IDR 12,476,000. By applying a partial budget analysis, the tegel farmers obtained an R / C value of 1.21, and the Jarwo farmers obtained an R / C value of 1.87. If the MBCR value is calculated, it is obtained 2.59, which means that every IDR 1000 spent will result in IDR 2,590.

3.2.2. Predicted factors are affecting the performance of the Jarwo planting system. Based on the results of interviews in the field, it was revealed that the respondents' perceptions of the Jarwo planting method were not in one view. According to respondents, the constraints in applying the Jarwo planting method were: the planting method was relatively more complicated than the tegel system because it was different from the custom of the Tegel with the same spacing. While in Jarwo, the spacing in rows is not the same as between rows. In rows are narrower than between rows. With different planting methods between rows and in rows, the planting time takes longer. There is the spacing that is not symmetrical, and some parts are left blank. This condition demands more concentration for planting power. Besides that, the planting cost of the Jarwo method is higher than the Tegel method. At the time of this assessment, the tegel planting piece-rate wage was around IDR 650,000 per ha, while the wage for Jarwo was IDR 750,000 to IDR 800,000 per ha. Nevertheless, the characteristics of innovation on perception and attitude affect the farmers' adoption model [19]. In addition, technology adoption may be influenced by various socio-economic factors and the degree of risk aversion [20].

4. Conclusion

The Jarwo planting system has been proven economically to be more profitable than the tegel system, either the yield or the production cost. The R/C value of Jarwo and tegel planting system obtained were 1.87 and 1.21, respectively. The higher productivity in Jarwo system might be affected by the microclimate environment improvement. The expansive space among the plant population causes the opening of space for growth and maximum sunlight capture. Moreover, plant maintenance such as weeding, fertilizer application, and controlling pests and diseases are more effective, even though the planting method was relatively more complicated than the tegel system. In Conclusion, Jarwo planting system has a positive impact on farmers' income.

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