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Financial Feasibility Assessment of Sweet Potato Cultivation Technology Packages Application in Tidal Swamp Land

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Abstract

Sweet potato is consumed as a source of carbohydrate as a substitute for essential food (rice). Due to limited area in Java island, Indonesia, the expansion of sweet potato could be cultivated in tidal swamp land. Therefore, this research was aimed to determine the financial feasibility of sweet potato technology packages in tidal swamp field. This research was carried out in tidal swamp fields: Roham Village, Wanaraya District, Barito Koala Regency, and South Kalimantan Province, Indonesia from March to July 2019. This study compared two innovative and existing technologies. The innovative technology introduced to the farmers emphasized on intensive processing in order to reduce the occurrence of the main pests of sweet potato in tidal fields. Innovative technologyy includes tillage done with plows and rakes. The results of this research showed that application of sweet potato cultivation technology packages with improved tillage, land cover with mulch, pest control using chemical fungicides and shallot extracts has proven to be financially feasible. Existing farmers (local variety) who switch to innovative technology using Sari variety, the profit earned increased by 232.47%. Technically, the application of the tuber yield innovative technology for Sari variety was higher, both controlled using chemical insecticides and innovative technology of 18.25 and 24.15 tons/ha, respectively. The implementation of the introduced cultivation technology package was able to increase local sweet potato production to the superior Sari variety by 96.82% compared to the farmer technology package at the same location. R/C and B/C ratio > 1 for innovative technology shows that innovation technology is feasible to be developed at the researched location.

Keywords: cultivation technology, financial feasibility, sweet potato, tidal land

1. Introduction

Sweet potato (*Ipomoea batatas* L.) in Indonesia is considered as secondary crop (*palawija*) after rice, which is consumed as a source of carbohydrate as a substitute for essential food (rice). Sweet potato mostly cultivated in Java island either in upland or in rainfed lowland after rice. However due to limited area in Java, the expansion of sweet potato could be cultivated in tidal swamp land. In Indonesia the tidal swamp land is quite large, reaching 33 million hectares, most of which are potential land for the development of cassava and sweet potato (Nugroho et al., 1992). The latest digitization result of tidal swamp land in Indonesia that was 34.93 million ha (BBSDLP, 2014).

In 2018, the provinces of West Java, East Java and Central Java contributed a total of 36.48% of national production, followed by the provinces of Papua, East Nusa Tenggara and North Sumatra, which contributed with 17.38%, 8.89%, and 5.54%, respectively. The national productivity of sweet potato reached 18.02 t/ha, which is still much lower than the yield potential of several superior varieties which reach 25-30 t/ha of fresh tubers (BPS, 2018). This shows that the potential to increase production through the development of planted areas is still very large. Considering that the development must be adjusted for areas that have agro-climatic compatibility with sweet potatoes.

Steady swamp land in South Kalimantan is around 208,893 ha which is divided into three groups, namely organic soil (*peat*), river sediment mineral soils (*embankments*), and mineral soils of marine sediment, by which about 37% of this area has been used for agriculture (Arifin et al., 2006; Raihana, 2012; Arsyad, 2014; Panggabean & Wiryawan, 2016; Salamiah & Kumalawati, 2017). However, the land use still faces various obstacles, namely in the form of physico-chemical land. According to Sarwani et al. (1994) these obstacles were in the form of waterlogging, land physical conditions, high soil acidity, presence of toxic substances (Al, Fe and H_2S), saltwater intrusion, and low soil fertility.

Sweet potato has the opportunity to be cultivated in the tidal swamp lands of South Kalimantan. Sweet potato production in this province reached 23,421 tons in 2014 with a productivity of 12.9 tons/ha (BPS, 2018). According to the report of Notohadiprawiro and Maas (2006), the productivity of cassava and sweet potato in tidal land is still low. Therefore, it is the opportunity to improve sweet potato productivity through land management physically, biologically, and chemically. Barito Koala Regency, South Kalimantan Province, is one the sweet potato production area, however it has several problems such as the presence of endemic cylas and scab diseases resulting in low tuber yield. The sweet potato cultivated by the local community is a local variety with superior taste, but it is very susceptible to tuber borer attack caused by *Cylas formicarius* and scab disease caused by *Sphaceloma batatas* (Prayogo & Bayu, 1991).

The emergence of these pests and diseases also occur in the dry season when many tubers are exposed due to the break of soil surface. With the addition of mulch, the enlargement of width and height of mounds, as well as soaking of the land, the tubers formed will be protected from *C. formicarius* imago (Chalfant et al., 1990; Chalker-Scott, 2007; Dada et al., 2020).Several research results indicated that the productivity of sweet potato in tidal fields reached 10 - 20.22 tons/ha with local varieties and depends on the use of fertilization inputs and land preparation (Galib, 2014; Faidah et al., 2015). Widodo et al. 2018 reported that in 2017, Simpangjaya, South Kalimantan, sweet potato variety Beta 3 yielded 14.66 tons/ha which was higher than the local variety (10.72 tons/ha). Zahoor et al. (2016) and Laxminaraya et al. (2016) suggested to produce sweet potato with productivity of 15.39 tons/ha can be conducted by applying fertilizer of 100 kg of Phonska + 10 tons of manure + 5 tons of litter as mulch + 750 kg/ha lime (dolomit).

Land management could be conducted using technology components consisted of superior varieties, dolomite, land covering with straw mulch, enlargement of the width and height of the mounds, increasing the dosage of organic and inorganic fertilizers, as well as controlling tuber borer using the entomopathogenic fungus *Beauveria bassiana* and scab disease using vegetable pesticides from shallot extract. The superior variety used was Sari which has early maturity (3.5 months), resistance to the main pests of sweet potato, namely boleng (*Cylas formicarius*), and high productivity (40 tons/ha). Application of dolomite (lime) increased the efficiency of Phosphorus (P) fertilization, even extracting soil P bound by Aluminium (Al) or Iron (Fe) (Subiksa et al., 1998), could inhibited the rate of soil acidification (Smith, 1997; Hartatik et al., 1999; Abiodun, 2010; Chen et al., 2017).

The use of mulch from rice straw and other crop residues can be used to replace the function of turning (lifting) the sweet potato tendrils, making it more efficient economically. Additional mound width and height are needed so that the tubers are well protected or covered with soil. One of the several ways to increase soil and plant productivity and environmental sustainability is through an integrated nutrient system that combines organic fertilizers with inorganic fertilizers. Organic fertilizers were usually given together with the manufacture of mounds. Manure as much as 10 t/ha without the addition of inorganic fertilizers was able to produce sweet potato up to 28 tons/ha, harvested at four months of maturity age in alluvial soil (Widodo et al., 2018). According to Waluyo and Mok (1994), the intensity of boleng pest attacks in the dry season increased by up to 70%. Therefore, the biological control use entomopathogenic fungus *B. bassiana* and botanical pesticide of shallot extracts can be relied on to suppress the main pest and disease attack of sweet potato (Abiodun, 2010; Sumartini, 2014; Saputro et al., 2019). The sweet potato cultivation technology package may increase farmers' production and income, therefore, the current experiment was undertaken with the objective to determine the financial feasibility of sweet potato technology packages in tidal swamp fields.

2. Method

2.1 Location and Time of Research

This research was carried out in tidal swamp fields, Roham Village, Wanaraya District, Barito Koala Regency, South Kalimantan Province, Indonesia from March to July 2019. The location determination was carried out purposively by considering that sweet potato was a nominated food crop commodity. However, it had problems with the presence of endemic cylas and scab diseases resulting in low yielding local varieties. The research covered an area of 2.0 ha which consisted of 1.0 ha of farmer's existing technology and 1.0 ha of innovation technology.

2.2 Research Approach

This study compared two technologies, named innovative and existing technologies. The innovative technology introduced to the farmers emphasized on intensive processing in order to reduce the occurrence of the main pests of sweet potato in tidal fields. Innovative technology include: tillage done with plows and rakes. The varieties used were superior variety Sari and local variety (used as a check or comparison). Dolomite was given by mixing it with manure and for the ground cover as much as 2 tons/ha of straw mulch was laid. The mounds measure 150 cm wide and 60 cm high. They were given 3 tons/ha of organic and inorganic fertilizers, manure and 400 kg/ha of Phonska. Tuber borer control was done using the entomopathogenic fungus *Beauveria bassiana* and scab disease was done using vegetable pesticides from shallot extract.

The existing technology was a recommended technology commonly used by farmers. Existing technology consisted of various components, almost the same as the innovative technology component. The striking difference in the existing technology was that the land was not covered using mulch, pest and diseases were controlled using chemical pesticides, in addition to increasing the dosage of fertilizer and dolomite. The components of both existing and innovative technologies in sweet potato production in tidal fields is presented in Table 1.

Data and observations made include costs and farm yields. Analysis to show an increase in farmer's income was carried out by input-output analysis. The data collected was primary obtained from direct observation and recording of farmers who were directly involved in sweet potato cultivation research activities which include soil cultivation, planting, fertilization, weeding, pest control and harvesting. Data related to technical aspects recorded were the yield of healthy sweet potato tubers. Data related to the financial aspects collected were: (a) used and cost of inputs, (b) used and financing of labor, (c) Revenues by farmers from sweet potato production, (c) Selling prices, (d) Use of fertilizers and pesticides (needs and purchase costs), and (e) Use of labor (number and costs of labor for various activities).

2.3 Types of Data and Analysis Methods

2.3.1 Data Collection Technique

The data used in this study came from secondary and primary data. Primary data collection was carried out by means of observation, and direct interviews using a questionnaire, while secondary data was obtained from various sources, namely various agencies related to this research, both at the provincial and district levels as well as from various literatures. Data collection includes sweet potato cultivation activities, namely land preparation, planting, weeding, pest control and harvesting. This data was needed to obtain information on financial aspects, however, the technical aspects were still being observed as supporting data.

2.3.2 Data Analysis

Economic feasibility analysis was used to see how much income and sweet potato production was produced by farmers using both existing and innovative technologies. Farm income was counted by analyzing the cost and income of farming (Lipsey, 1997). Mathematically it can be written as follows (Rahim & Hastuti, 2007):

$$\pi = TR - TC \tag{1}$$

where, π = Profits from sweet potato farming (Rp); TR = Total revenue from sweet potato farming (Rp); TC = Total cost of sweet potato farming (Rp).

Qualitative data analysis used descriptive methods to explain the characteristics of farmers. The quantitative data analyzed were farm income, Break Event Point (BEP), revenue and cost (R/C) ratio, Benefit Cost (B/C) Ratio, and Marginal Benefit Cost (MBC) Ratio. Farming revenue is a multiplication between the production obtained by the farmer and the selling price This definition can be formulated as follows:

$$a = R/C \tag{2}$$

where, R/C = ratio of revenue and cost; R = revenue (Rp/ha); C = Cost (Rp/ha).

With a decision:

R/C > 1, farming is economically profitable;

R/C = 1, farming is economically at the break-even point (BEP);

R/C < 1, farming is not economically profitable (loss).

It is believed that the profit or value of the introduced technology package is higher than the farmer's technology package. For that, the feasibility of the two types of technology packages (farmer method and introduced technology packages) need to be known. Farming feasibility was a measure to determine whether this business is feasible or not feasible. Here in the sense of whether it can produce a benefit or not. To determine the feasibility level of changes in technology innovation components, use the break-even point analysis approach (BEP production) and the price break-even point (BEP price) using the analysis of losses and gains through marginal B/C or the ratio of profit and marginal costs (MBC) ratio. Benefit Cost Ratio (B/C ratio) is calculated based on the equation:

$$\text{B/C ratio} = \text{Total Cost/Total Production} \tag{3}$$

where,

If the B/C ratio > 0 means that the farming has potential financial to develop;

If the B/C ratio = 0 it means that the farm is at point break-even (BEP);

If the B/C ratio < 0, it means that the farming has no potential financially to develop.

To find a point, in units or rupiah, that shows costs equal to income, a break event point (BEP) analysis is used (Hidayah, 2016). According to Malian (2004), the Marginal Benefit Cost (MBC) Ratio is calculated based on the following equation:

$$\text{MBC Ratio} = (\text{Gross receipts of I} - \text{Gross receipts of P})/(\text{Total cost of I} - \text{Total cost of P}) \tag{4}$$

where, I = Innovation Technology; P = Existing Technology.

If the MBC Ratio value is > 1, then the pesticide-free technology package is considered economically feasible. Break Event Point (BEP) is calculated by differentiating production BEP and price BEP with the following equations:

$$\text{BEP Production} = (\text{Cost of production})/(\text{Price of production}) \tag{5}$$

$$\text{BEP Price} = (\text{Cost of production})/\text{Productivity} \tag{6}$$

3. Results and Discussion

3.1 Sweet Potato Productivity

The implementation of the introduced cultivation technology package was able to increase local sweet potato production to the superior Sari variety by 96.82% compared to the farmer technology package at the same location. This occured especially with the superior sweet potato varieties that have the opportunity to be widely used. From this research, the application of existing technology components, both on local varieties and superior varieties of Sari, were able to produce tuber yield of 12.27 and 18.25 tons/ha, respectively. These results were still far from the potential of research results (Sari variety) which can reach 30.0-35.0 tons/ha (BALITKABI, 2016).

By using innovation technology, the tuber yield for Sari variety was higher, both in controlled using chemical insecticides and innovative technology, 18.25 t/ha and 24.15 t/ha, respectively (Figure 1). Giving straw mulch to sweet potato plantations increased the yield of sweet potatoes, in addition to suppressing weed growth, maintaining moisture and soil fertility.

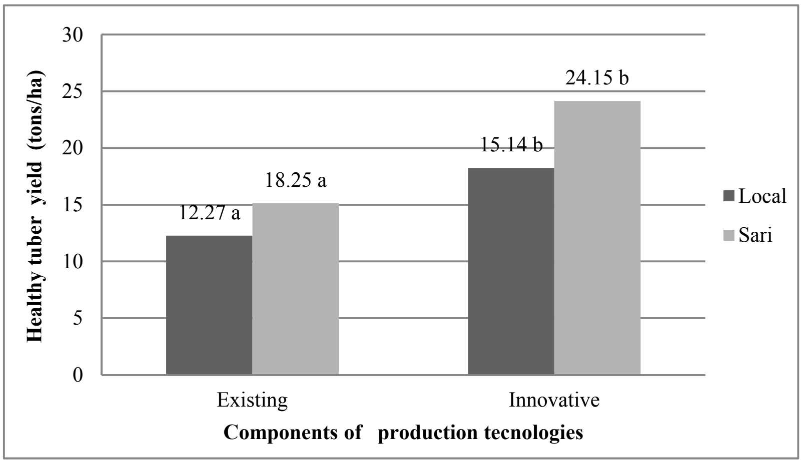

Figure 1. Average yield of local variety and superior Sari variety using chemical insecticides (existing) and land management (innovative) technologies

3.2 Cost Structure and Feasibility of Cultivation Technology

3.2.1 Input Requirements

The results of economic farming analysis at the research level showed that the use of innovative technology required higher input costs than existing technology (Table 1). The high cost was due to the high production facilities in the form of increasing the amount of dolomite and manure of 1 ton/ha each, 200 kg/ ha of Phonska fertilizer and the availability of straw mulch, the cost was Rp. 7,300,000 (equal to 521.43USD)/ha, while in the existing technology reached Rp 2,100,000 (149.99 USD)/ha. The use of fungus biopesticide (*B. bassiana*) and vegetable pesticides reached Rp 2,450,000 (175.00 USD)/ha or 10.86% of the total input costs, whereas in existing technology, insecticides and fungicides were required at a cost of Rp 1,359,000 (97.07 USD)/ha or 8.36% of total input costs. The total input costs for existing and innovative technology were Rp 22,550,000 (1610.71 USD) and Rp 16,259,000 (1161.36 USD)/ha, respectively. If farmers want to switch to using innovative technology, the costs required to provide production facilities were Rp 6,291,000/ha (449.36 USD) or increased by 38.69%.

Tabel 1. Material input costs for the innovative package and existing sweet potato cultivation technologies in the tidal area of Barito Koala Regency, South Kalimantan, Indonesia, 2019

Descriptions	Production Technologies					
	Innovative			Existing		
	(Rp)*	(USD)*	(%)	(Rp)	(USD)	(%)
Stem cuts for planting	12,800,000	914.29	56.76	12,800,000	914.29	78.73
Phonska	1,000,000	71.43	4.43	500,000	35.71	3.08
Manure	1,200,000	85.71	5.32	800,000	57.14	4.92
Dolomite	1,600,000	114.29	7.10	800,000	57.14	4.92
Mulch straw	3,500,000	250.00	15.52	-	-	-
B. bassiana (fungus biopesticide)	1,250,000	89.29	5.54	-	-	-
Shallot extract (herbal pesticide)	1,200,000	85.71	5.32	-	-	-
Insecticide	-	-	-	839,000	59.93	5.16
Fungicide	-	-	-	520,000	37.14	3.20
Total input costs/ha	**22,550,000**	**1610.71**	**100.00**	**16,259,000**	**1161.36**	**100.00**

Note. * 1.0 USD (US Dollar) = Rp 14,000 (Indonesian Rupiah).

3.2.2 Labor Requirement

Sweet potato farming used a lot of male labor because of the heavy work involved in land cultivation, planting and harvesting. Leovita et al. (2015) stated that labor was the biggest farming cost component in sweet potato farming. The use of labor involved elements of labor in the family and also outside the family. Therefore, the costs calculated in this study included labor costs in the family. The use of labor in the family did not burden the farmers too much in terms of financing their farms. Wages differ according to their activities. For the activities of tillage, plotting for planting pads, and mounting, the payment was made in bulk of Rp 1,500,000 (107.14 USD)/ha, Rp 7,000,000 (500.00 USD)/ha, and Rp 4,500,000 (321.43 USD) /ha, respectively. However for planting, fertilizing, controlling pests and diseases, turning tendrils and harvesting harvest, farmers provided a wage of Rp 55,000 (3.93 USD)/4.5 hours.

Cultivation and harvesting activities required a lot of manpower (labor). Land processing was done by workers outside the family, while for planting, fertilizing, controlling pests and diseases, turning tendrils and harvesting are carried out by workers within and outside the family. The addition of labor input for land processing activities is 41.67% higher than the existing method. This was due to the technology innovation, doing the plowing and rake activities twice each. However, the workforce for pest control and innovation technology was 11.11% lower than the existing technology. If farmers switch to innovative technology, the costs required for labor increased by 24.36%. The labor input costs for the innovation package and the existing sweet potato cultivation is presented in Table 2.

Table 2. Labor input costs of sweet potato cultivation technologies in the tidal swamp area of Barito Koala Regency, South Kalimantan, Indonesia, 2019

Descriptions	Production Technologies					
	Innovative			Existing		
	(Rp)*	(USD)*	(%)	(Rp)	(USD)	(%)
Soil tillage	1,500,000	107.14	11.36	1,500,000	107.14	14.13
Plotting for planting pads	7,000,000	500.00	53.02	4,500,000	321.43	42.39
Planting	715,000	51.07	5.42	715,000	51.07	6.74
Fertilizing	550,000	39.29	4.17	550,000	39.29	5.18
Controlling pests and diseases	1,512,000	108.00	11.45	1,701,000	121.50	16.02
Turning tendrils	825,000	58.93	6.25	825,000	58.93	7.77
Harvesting	1,100,000	78.57	8.33	825,000	58.93	7.77
Total of labor input costs	**13,202,000**	**943.00**	**100.00**	**10,616,000**	**758.29**	**100.00**

Note. * 1.0 USD (US Dollar) = Rp 14,000 (Indonesian Rupiah).

3.3 Revenue, Benefits, and Financial Feasibility

The results of research by Masithoh et al. (2017) and Chasanah et al. (2018) showed that the input costs of production facilities took a large portion of the production costs of sweet potato farming, both in innovative and existing technologies, namely 63.07% and 60.50%, respectively. At the time of the research, the price of sweet potato reached Rp. 3,500 (0.25 USD)/kg at the farmer level, while the yields of both local variety and superior Sari variety using innovation technology reached Rp 3,600 (0.26 USD)/kg. The price difference was due to the bigger, cleaner and healthier sweet potato Sari variety. By using Sari Variety and innovative technology, farmer income increased by 38.52% compared to the income of farmers using local variety in the existing way, namely from Rp 42,910,000 (3065.00 USD) to Rp 64,728,000 (4623.43 USD) (Table 3). And if existing farmers (local variety) switched to innovative technology using Sari variety, better land management and control of non-chemical pesticide, the profit increased by 232.47%.

An agricultural commodity is feasible to be developed in terms of increasing productivity and also from the aspect of its agricultural economic feasibility. Sari superior variety using innovative technology is feasible to be developed in South Kalimantan, because it reached a B/C ratio > 1. The B/C ratio achieved was 1.54, showed that each additional investment as input for innovative cultivation techniques was able to provide a larger additional income compared to local varieties with existing technology. The application of innovative technology with improved soil cultivation, use of vegetable pesticides and the use of high yielding varieties also provided a high MBCR relative to existing technology. The results of the MBCR analysis reflected the feasibility of changing technology from existing technology to innovation technology. The results showed that if farmers (existing) using local variety switch to innovative technology while still using local variety, then the MBCR achieved is 2.60 and if farmers (existing) with local variety switch to using Sari variety using innovative technology then MBCR is 5,51. This means that for every Rp 1,000 (0.14 USD) increase to transform existing technology into innovative technology, there will be an increase in total income of Rp. 5,510 (0.39 USD) (Table 4). This condition causes the innovative technology to have the opportunity to be adopted by farmers, if it can provide a profit of at least 30% higher than what farmers have been used to. BEP productivity with existing technology (local variety) is 7,617 kg/ha at a selling price of Rp 3,500 (0.25 USD)/kg, while in innovative technology using the Sari variety, BEP of the productivity is 9,733 kg/ha at a selling price of Rp 3,600 (0.26 USD)/kg, therefore, total production costs can be covered. Technically, the amount of BEP productivity was achieved at 62.63% of the real productivity of the existing farmer method, and the BEP productivity of innovation technology was achieved at 40.14% of the real productivity. From this analysis, it shows that technically and financially that sweet potato farming can provide benefits for farmers.

Table 3. Tuber yield, production costs, revenue and benefit of sweet potato cultivation package technologies in tidal swamp land in Barito Koala, South Kalimantan, Indonesia, 2019

Cultivation package technologies	Tuber yield/ha	Production costs/ha		Revenue/ha		Benefit/ha	
	(tons)	(IDR)*	(USD)*	(IDR)*	(USD)*	(IDR)*	(USD)*
Varieties in Existing							
Local	12.26	26,660,000	1904.29	42,910,000	3065.00	16,250,000	1160.71
Sari	18.37	26,660,000	1904.29	64,295,000	4592.50	37,635,000	2688.21
Varieties in Innovative							
Local	17.98	35,037,000	2502.64	64,728,000	4623.43	29,691,000	2120.79
Sari	24.74	35,037,000	2502.64	89,064,000	6361.71	54,027,000	3859.07

Table 4. The R/C ratio, B/C ratio, MBC ratio, and BEP of sweet potato cultivation package technologies in tidal swamp land in Barito Koala, South Kalimantan, Indonesia, 2019

Description	Existing		Innovative	
	Local	Sari	Local	Sari
R/C ratio	1.61	2.41	1.85	2.54
B/C ratio	0.61	1.41	0.85	1.54
MBC ratio	0	0	2.61	5.51
BEP productivity (kg/ha)	7,617	7,617	9,733	9,733
BEP price (Rp/kg)	2,175	1,451	1,949	1,416
BEP price (USD/kg)	0.16	0.10	0.14	0.10

4. Discussion

The difference in the growing environment of sweet potatoes caused the development and yield of sweet potatoes both in quality and quantity to be different (Nedunchezhiyan et al., 2012). Giving straw mulch to sweet potato plantations increased the yield of sweet potatoes, in addition to suppressing weed growth, maintaining moisture and soil fertility (Oliveira et al., 2010; Agbede & Adekiya, 2011; Wees et al., 2016; Kochmal-Marczak et al., 2018). This was proven by using innovation technology, the tuber yield for Sari variety was higher, both in controlled using chemical insecticides and innovative technology, 18.25 t/ha and 24.15 t/ha, respectively (Figure 1). The results of the research by Prayogo et al. (2018) indicated that application of *B. bassiana* without a combination with mulching was able to obtain healthy tuber yield up to 20 tons/ha, the addition of mulch treatment without the combination of *B. bassiana* produced tuber yields of around 15 tons/ha, whereas without pest control only produced healthy tubers of about 8 tons/ha in tidal fields.

The application of sweet potato cultivation technology packages with improved tillage, land cover with mulch, pest control using chemical fungicides and shallot extracts has proven to be financially feasible. Existing farmers (local variety) who switch to innovative technology using Sari variety, the profit earned increased by 232.47%. Technically, the application of the tuber yield innovative technology for Sari variety was higher, both controlled using chemical insecticides and innovative technology of 18.25 and 24.15 tons/ha, respectively. The implementation of the introduced cultivation technology package was able to increase local sweet potato production to the superior Sari variety by 96.82% compared to the farmer technology package at the same location. R/C and B/C ratio > 1 for innovative technology shows that innovation technology is feasible to be developed at the research location. Subagiyo et al. (2005) and Sidik (2007) stated that the relative economic benefits of innovation from an economic perspective must be more profitable, at least moving from 25 to 30% if the local community wants to adopt it. Social factors and financial aspects in the form of incentives play an important role in determining technology adoption (Sargent et al., 2012; Talukder, 2012; Roumani et al., 2015; Sambodo et al., 2010 in Sirnawati et al., 2019).

This technology package could be introduced in other tidal swamp areas outside the Barito Koala Regency and outside the South Kalimantan Province of Indonesia to support the goverment's food security programs as well as to increase the farmer's welfare.

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