**Study of Technology to Increase Productivity And Economic Feasibility of Soybeans on Tidal Lands In Jambi Province, Indonesia**

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**Abstract.**

Soybean crops are important food crops after rice and corn, where the needs are always increasing every year. The purpose of this study is to compare soybean cultivation technology with the productivity and economic feasibility of soybean farming in tidal marshlands typology of acid sulphate land and waterlogging type C. This assessment was carried out on tidal land owned by farmers with a planting area of 1.5 ha in May-August 2019 in Bandar Jaya Village, Rantau Rasau District, Tanjung Jabung Timur Regency, Jambi Province. The methodology used applies 3 packages of soybean cultivation technology: 1) Tillage + 1000 kg ha-1 organic fertilizer (manure + Dolomite) + 50 kg ha-1 Urea + 100 kg ha-1 SP 36 + 50 kg ha-1 KCl (Integrated Crop Managements : ICM 1), 2) No tillage + 1000 kg ha-1 organic fertilizer (manure + Dolomite) + 50 kg ha-1 Urea + 100 kg ha-1 SP 36 + 50 kg ha-1 KCl (ICM 2), and 3) No tillage + Urea 50 kg ha-1 Urea + 50 kg ha-1 SP 36 (Farmer's way). The study showed that ICM-1 technology was able to increase productivity by 2.07 times, and economically increased farm profits by Rp 9,840,000/ha with an MBCR value of 2.20. so that the ICM-1 soybean technology is feasible to apply. In order for the development of ICM technology to continue, it is necessary to support production facilities and affordable prices, the use of alternative fertilizers and the use of biological agents and seed breeding by farmers. Guidance and assistance by officers and dissemination through information and communication technology as well as direct dissemination.

**Keywords:** Swampland, Technology Studies, Soybean Technology Cultivation, Soybean Productivity, Soybean Economic Feasibility.

**Introduction**

Indonesia's population in the last five years has increased by 1.4% per year, which has placed Indonesia as a developed country in the world with a population of more than 267 million (Hadi, Zahrita and Haris, 2020). Soybean (Glycine max L. Merrill) comes from East Asia and is widely in China, Manchuria, Korea and Japan, is an important food ingredient in Asia, grown traditionally and commercially in highland areas and various climatic conditions (Nget *et al.*, 2021). The protein content of soybean plants is quite high, which is around 40% to 42%, the second highest after peanuts and fats (18% to 22%) which consists of 85% unsaturated and cholesterol-free fatty acids, so it is very good for health (Karyawati and Puspitaningrum, 2021). Soybean with its multiple uses, is one of the most important crops worldwide (Sobko *et al.*, 2020). The needs of the community reach 2.5 million tons of dry soybeans per year, consisting of consumption for direct humans of 2 million tons, as animal feed of 3,000 tons, for seeds of 39,000 tons and non-food industry of 446,000 tons and dairy industry of 49,000 tons (Meithasari, Endriani and Rumbaina, 2020).

Soybeans are a nutrient-rich food commodity, used as animal feed and industrial raw materials. Its needs continue to increase along with population growth and people’s nutritional awareness. Soy has health benefits, containing isoflavones that prevent heart damage, osteoporosis and tumors. Soy is also anti atherosclerosis and helps with menopausal syndrome, diabetes mellitus, colon cancer and prostate cancer (Hasanah, Hanum and Hidayat, 2019). Soy with a high protein content and ideal amino acid composition, can be used as an excellent feed supplement, especially for monogastric animals (Karges *et al.*, 2022). Soy is also a cheap source of protein and contains high protein and has become a common meal for residents in Asia especially as tofu, tempeh and soy milk (Hendrawati *et al.*, 2021). Soy plants are a source of protein containing essential amino acids (Zhao *et al.*, 2018). Soybeans are a food security crop because they are multi-benefit to humans, especially in rural economies (Asodina *et al.*, 2020). Almost all over the world, soybeans are the most important source of protein for humans and livestock (Belay, 2008). Soybeans (Glycine max L.) are the most nutritious and economically valuable legume crop in the world (Latawiec *et al.*, 2021). Soybean (Glycine max L.) is also the world's premier high-quality oil and protein producing seed crop (Radocaj *et al.*, 2020). In North, South America and Asia, the soybean crop (Glycine max) is the fourth most important seed crop in terms of global production (Matthews *et al.*, 2022). In the twentieth century, soybean plants were also a significant and miraculous source of protein and vegetable oils for human and animal use (Meseldžija *et al.*, 2020).

Soybeans are a key ingredient in the production of tofu and tempeh, making them popular food choices among the Indonesian people. Intercropping soybean and corn is an effective method used by farmers in Southwest China to increase crop yields and optimize nutrient utilization (FU *et al.*, 2019). Many countries are implementing crop integration and relays in increasing food production (Yang *et al.*, 2014). The need for soybean crops is constantly increasing. Currently, soybean production in Indonesia is only able to meet around 30-40% of national consumption of 2.6 million tons per year (Krisdiana *et al.*, 2021). In some countries soybean crops are an important crop such as in Northern Ghana which is also dominated by smallholder farmers traditionally with low adoption of increased soybean production (Mahama *et al.*, 2020). In other European countries, interest in protein-rich crops, particularly soybeans (Glycine max L. Merr), has increased in recent decades (Toloi *et al.*, 2021).

Soybean crops are now the leading source of protein among crops worldwide (Chander *et al.*, 2021). Because of its high protein and mineral content, the soybean plant (Glycine max L. Merr) is also known as a miracle plant (Mubeen *et al.*, 2021). The protein content of soybean plants is twice as high as that of other vegetable crops or cereals (Ratmini, Herwenita and Irsan, 2021). Almost every field in the soybean business, which produces protein and oil, has the potential to boost production and economic efficiency (Muniz *et al.*, 2022). Soybean crops are currently also the primary source of protein among crops in the world (Toloi *et al.*, 2021). The soybean plant (Glycine max L. Merr) is often also referred to as a miracle plant doe to its high protein and minerals content (Chander *et al.*, 2021). The protein content of soybean plants is twice as much as the protein content of other vegetable crops or grains ((Mubeen *et al.*, 2021). Almost every field in the soybean business, which produces protein and oil, has the potential to boost production and economic efficiency (Muniz *et al.*, 2022).

The area of swampland in Indonesia reaches 33.4 – 39.4 million ha, which is spread across the coastal plains of Sumatra, Kalimantan, Irian Jaya and Sulawesi with soil types Histosol, Entisol, and Inceptisol. Of this number, about 20.1 million ha is tidal marshland. The tidal marshland that has been cleared is around 7.55 million ha and 10.2% of it is managed for agriculture, so there are still 5.25 million ha available which has the potential to be used further. The problems faced in the development of tidal marshlands are mainly low soil fertility and high soil pH (Anapalli *et al.*, 2022). To ensure food security in line with the world's population growth, intensification of sustainable land use practices in preserving the environment must be a concern (ZHU *et al.*, 2019).

Jambi Province is one of Sumatra's soybean production centers, with a swampland area of 684,000 ha, or nearly 12% of its total area. There are 252,983 ha of tidal marshland and 41,021 ha of swamp land (non-tidal) marshland among the regions that have been opened and reclaimed. In general, swamp soils are acidic and low in nutrient content, with Histosol, Entisol, and Inceptisol being the prominent soil types (Hafif and Khaerati, 2021). Lack and excess water in the soil (less oxygen) will also affect soybean production due to root rot(Liu *et al.*, 2020). The application of nitrogen (N) and phosphorus (P) inorganic fertilizers is very important for the supply of plant nutrients to obtain maximum production (Tantawizal *et al.*, 2021). Agricultural experts continue to strive to find the right and sustainable management technology so that peatlands become productive agricultural land (Salama and Abdel-Moneim, 2021).

The early growth of soybean crops in tidal marshes is less good due to the negative effects of soil saturation, but eventually soybean plants can adjust and their growth becomes better. In terms of complexity and cultivation requirements, soybean crops differ from other crops in terms of tillage and soil preparation (Slameto, Meidaliyantisyah and Wibawa, 2021). This method has been shown to boost soybean crop productivity by overcoming and preventing pyrite oxidation in tidal marshlands (Jumakir and Abdullah, 2009). Tidal marshlands can help enhance national food production with the availability of swampland technology advancements. Climate change's potential repercussions, particularly on resources critical to human well-being such as water availability and agriculture, have a direct impact on economic activity and food security (Sohn *et al.*, 2021). In places with low rainfall levels, efforts are required to prepare the ground in such a way that rainwater retention amounts are maintained (Surahman *et al.*, 2018).

The results showed that this swampland has enough potential for agricultural business both for food crops, plantations, horticulture, and livestock businesses. In the future, swampland will be very strategic and important for agricultural development in supporting food security and agribusiness efforts. In the development of soybeans in tidal marshlands face problems related to the physio-chemical properties of the soil, such as water-saturated, acidification, and poisoning al. Naturally, the land is water-saturated or shallowly stagnant throughout the year or several months of the year. These conditions have a deleterious impact on soybean growth and production, depending on the variety grown, the length of inundation, and the stage of growth. Soybean productivity has ranged from 1.3 to 1.5 tons per acre on dry ground during the rainy season or in rice fields during the dry season (Adi *et al.*, 2019). To boost soybean output, many methods of bridging production gaps are required, including intensification, extensification, and diversification based on prospective resources (Adi *et al.*, 2019). Including the utilization of hay resources is also becoming more important (Ghulamahdi, Welly and Sagala, 2018).

Tidal soils have traditionally been cultivated by locals and transmigration people in Jambi Province. The biggest challenge for tidal soybean crops is the high pyrite content, which causes the soil pH to be low (acidic) when pyrite is oxidized. Food crops cultivated other than rice are soybeans. Soybean crops in tidal land are cultivated in Rantau Rasau District and Berbak District, Tanjung Jabung Timur Regency. Soybean productivity in Jambi Province is around 1.37 t ha-1, soybean productivity constraints in the tidal land of Jambi Province are caused by the availability of limited quality seeds, planting time, drought/water management, fertilization, disease pests, post-harvest, and prices. To increase soybean production higher, one of which can be pursued through plant breeding programs (Karyawati and Puspitaningrum, 2021). Spacing and determining the number /population of soybean plants per clump, is one of the recommended cultivation technology emphasizes that are believed to increase soybean yields per unit area (Caetano *et al.*, 2018).

Soybean productivity in the area can be enhanced by utilizing the agroecosystem through a rice-soybean planting pattern. However, the current soybean cultivation technology in tidal marshlands boosts production, income and farmer welfare. Additionally, the plating pattern of soybeans and corn is recommended in order developing countries due to its water-saving capabilities (Gawęda *et al.*, 2020). Crop rotation and intercropping of soybean crops are also commonly used in Southwest China, one of the most densely inhabited agricultural areas (Chen *et al.*, 2015). The soybean harvest is the most lucrative agricultural crop in Brasilia (Cattelan and Dall’Agnol, 2018).

Soybeans are one of the few crops that can produce more than half of the organic matter required in a single growing season (Pekša *et al.*, 2021), Soybean plants can be a good source of vitamins and minerals, and they have a good amino acid composition, with about 40%-45% protein and 18%-22% oil (Tolokonnikov *et al.*, 2021). There are numerous downstream soy products on the market, including soy milk, tofu, fermented soybean curd (tempeh), pudding, soy substitutes for meat, chicken, and fish, and soy can also be used to replace cocoa, coffee, and chocolate (Didorenko *et al.*, 2021). Soy, based on its composition, can be consumed by humans as part of a cholesterol-free diet (Meseldžija *et al.*, 2020).

The opportunity to boost soybean yield through intensification with the adoption of soybean farming technology through an integrated crop management (ICM) strategy remains relatively considerable. To improve national soybean output, multiple measures are required, including intensification in soybean production centers, extensification, and diversification, all of which require human resources (Tilba, Makhonin and Zelentsov, 2021). Soybean planting can also be done with technological innovations in corn and rice crops, with a system of interplants, production is higher than that of monoculture planting systems (Slameto, Meidaliyantisyah and Wibawa, 2021). Several research results show that the future prospects of swampland become very strategic and important both for food crops, plantations, horticulture and livestock businesses as well as supporting food security and agribusiness businesses (Wijanarko, Taufiq and Harnowo, 2016).

From the results of the study, it shows that with proper cultivation, the soybean productivity of tidal marshlands can reach more than 2 t ha-1. Soybean plants have a symbiotic relationship with rhizobia and arbuscular mycorrhizal fungi, so they do not require much chemical fertilizer, but still require chemical fertilizers in small quantities (Sohn *et al.*, 2021). One of the efforts to increase soybean productivity in tidal lands is to improve soil conditions by applying ameliorants or soil-improving materials in the form of lime. The purpose of this study is to compare cultivation technology against soybean productivity and the economic feasibility of soybean farming in tidal marshlands typology of acid sulphate land.

**Material and Methodology**

In a short period of time, the evaluation activities employ a rural knowledge approach (PRA= Participatory Rapid Appraisal). Bandar Jaya Village, Rantau Rasau District, Tanjung Jabung Timur Regency, Jambi Province is the site of the activities. The activity was carried out on tidal marshlands with a typology of possible sour sulphate lands and C water overflow type throughout the dry season from May to August 2019.

This assessment was carried out on farmers' land with a planting area of 1.5 ha and farmers applied 3 packages of soybean cultivation technology:

1). Tillage + 1000 kg ha-1 Organic Fertilizer (Manure + Dolomite) +50 kg ha-1 Urea + 100 kg ha-1 SP 36 + 50 kg ha-1 KCl (ICM-1)

2). No tillage + 1000 kg ha-1 Organic Fertilizer (Manure + Dolomite) + 50 kg ha-1 Urea + 100 kg ha-1 SP 36 + 50 kg ha-1 KCl (ICM-2)

3). Without tillage + Urea 50 kg ha-1 Urea + 50 kg ha-1 SP 36 (Soybean cultivation technology by farmers)

The components of the soybean cultivation technology package include tillage, the use of quality seeds, varieties, the use of organic fertilizers (manure and dolomite), Urea fertilizer, SP 36 and KCl as well as the control of opt. In detail, soybean cultivation technology and farmer technology are listed in Table 1.

Table 1. Technology package on the study of soybean cultivation technology in Bandar Jaya Village, Rantau Rasau

District, Tanjung Jabung Timur-Jambi Regency, Indonesia 2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Technology Components | Soybeans cultivation technology package | | |
| ICM-1 | ICM-2 | Farmer way |
| 1. | Tillage | Tillage | No tillage (NT) | No tillage (NT) |
| 2. | Seed | labeled/quality | labeled/quality | unlabeled |
|  |  | 40 kg ha-1 | 40 kg ha-1 | 40 kg ha-1 |
| 3. | Varieties | Devon 1 | Devon 1 | Anjasmoro |
| 4. | Planting system | Sowing of seeds | Sowing of seeds | Sowing of seeds |
| 5. | Plant distance | 40x15 cm | 40x15 cm | irreguler |
| 6. | Organic fertilizer |  |  | - |
|  | - Manure + Dolomite | 1000 kg ha-1 | 1000 kg ha-1 | - |
| 7. | An organik fertilizer (kg ha-1) |  |  |  |
|  | - Urea (46% N) | 50 | 50 | 50 |
|  | - SP 36 (36% P2O5) | 100 | 100 | 50 |
|  | - KCl (60% K2O) | 50 | 50 | - |
| 8. | Pest Control | Integrated pest control | Integrated pest control | System calendar |
|  |  | (base on observation) | (base on observation) | (scheduled) |
| 9. | Harvest and post harvest | Arit-Power thresser | Arit-Power threser | Arit-Power threser |

**Soybean Cultivation Technology How To Farmers**

Soybean planting by farmers is carried out in monocultures, but there are also farmers who grow them between oil palm crops and young rubber plants. Tillage is carried out no tillage (NT), namely spraying the grass with herbicides, cutting grass, and before planting, spraying herbicides again is carried out. Tillage occurs in April, and soybean planting occurs in early May using a direct plant system and without seed treatment, with insecticides. Plant trenches are typically not covered, and row spacing is erratic. Generally, the seeds utilized are no longer pure soybeans. Fertilization is carried out at the age of 10-15 days after planting and the fertilizer applied is 50 kg ha-1 urea and 50 kg ha-1 SP 36 by spreading. Weed control by herbicide spraying and control of plant-disturbing organisms (plants pest / PP) is carried out on a scheduled basis. For harvesting is carried out by sickle and threshing soybeans using a power thresher machine (Table 1). Soybean crops are a very important legume crop, it can be grown as an intercrop with corn, sugarcane, and sorghums crops. Intercropping of corn and soybean crops is the dominant planting model carried out in southwest China (FU *et al.*, 2019). Sustainable corn-soybean intercropping can promote efficient use of plant and soil nutrients, regulate soil nitrogen cycles and can improve the utilization of nitrogen fertilizers in corn and soybeans in western China (FU *et al.*, 2019). Soybean cultivation technology also requires assistance to farmers in accordance with the recommended SOP (Standard Operating Procedure) (Surahman *et al.*, 2018).

**Recommended Soybean Cultivation Technology.**

Technology to increase soybean farming productivity using an integrated crop management approach (ICM-1 and ICM-2), specifically tillage with and without tillage, the use of labeled / quality seeds, new high-yielding varieties, planting distances of 40x15 cm, Urea fertilizer, SP 36, KCL, manure, and dolomite (Table 1). Making / repairing worm channels for the regulation of water management so that waterlogging does not occur and for the washing process of elements that poison plants. Regular spacing to facilitate fertilization, weed control and pest control. Fertilizing is done by running 5-7 cm from the plant and covering with soil, while planting trenches filled with soybean seeds are coated with a mixture of manure and dolomite. The IPM system is used to control plant-disturbing organisms. The changes observed include agronomic aspects, namely: 1) plant height, measured at the time of harvest 2) number of branches, counted branches contained in plants 3) number of stuffed pods, counted pitted pods / contains on plants, 4) number of hollow pods, calculated non-serviced/empty pods on plants, 5) dry seed yield equivalent to moisture content of 12% t ha-1. The results of dry seeds t ha-1 were obtained from the calculation of the results of tile plots measuring 2 m x 5 m, then an economic analysis was carried out including R/C, and a partial budget analysis of MBCR (marginal benefit cost ratio) namely the ratio of recipients' increase to additional costs from treatment.

1. Farm feasibility (R/C)

R/C = Total receipts/Total costs

Provided that:

R/C > 1, farming is economically profitable

R/C = 1, farming is economically at breakeven (BEP)

R/C < 1, farming is economically unprofitable (loss)

1. MBCR partial budget analysis (Marginal Benefit Cost Ratio)

R(n+1) - Rn

MBCR = ----------------------

C(n+1)-Cn

R(n+1) = Revenue from tested treatment

Rn = Income from comparative treatment

C(n+1) = Cost of the tested treatment

Cn = Cost of comparative treatment

**Results And Discussion**

Field conditions include a typology of potential sour sulphate, in the upper layer (about 50 cm) it is gray and clay textured while in the layer below 50 cm it is brighter colored and water is out. It is likely that the soil at the site was formed from the results of river deposition and at a depth of >50 cm there is a layer of pyrite. At a depth of 0-20 cm the soil belongs to the loose, however, at a depth of >20 cm a layer of hard soil. A common planting pattern in paddy fields is rice-palawija. The crops cultivated are soybeans, corn, peanuts, and green beans. Among these crops, soybeans are the most widely grown, followed by corn, green beans, and peanuts.

In Rantau Rasau Subdistrict throughout the year there continued to be rains even though with varying intensity and distribution between months. If the wet month is a month with rainfall of >200 mm, then there are at least 5-6 wet months and 6 dry months or C3 agroclimatic classification. In the C3 agroclimatic zone, the appropriate planting pattern is rice – soybeans. Rainfall of 200 mm/month is the lowest rainfall limit for paddy rice, and rainfall of 100 mm/month is the lowest limit for palawija. Judging from the rainfall pattern, the choice of farmers to apply the rice-soybean planting pattern in Bandar Jaya Village, Rantau Rasau District, is an option that is in accordance with the agroclimatic zone Jambi Province. (Figure 1)



Figure 1. Monthly rainfall, rainy days and humidity data for Jambi Province 2010 – 2019,

Sulthan Thaha Airport, Jambi.

Based on the results of the analysis of soil samples taken at a depth of 0-20 cm that the soil pH averages 4.8 (classified as acidic), the content of organic matter is low to moderate which is indicated by the C-organic content of 1.67-5.14%. Potassium (K) content is very low (0.06-0.15 me/100 g), phosphorus (P) is very low to medium (4.3-41.4 ppm P2O5), Calcium (Ca) is low (1.2-3.7 me/100 g), Magnesium (Mg) is low to medium (0.4-2.3 me/100 g). Al-dd content ranges from 1.4-5.0 me/100 g, however H-dd is very low.

**Soybean Growth and Yield.**

Results analysis of the mean value equation (Test-T) showed that the soybean cultivation technology of ICM-1 and ICM-2 have a very significant effect farmer way on the parameter observed ICM-1 and ICM-2 have a very significant effect on the parameters observed, except for plant heigh which only has a not significant effect. Soybean growth and yield with the application of ICM-1 and ICM-2 technology, showing technology better growth compared to farmer technology (Table 2). The results of research by (Jumakir and Abdullah, 2009), reported that the growth and yield of soybeans obtained by the application of ICM technology showed relatively better growth and yields obtained with farmer technology. Factors that affect the growth of soybeans by farmers are caused by the tightness of soybean plants that grow so that there is competition between soybean growth, in addition to the influence of the dose of inorganic fertilizer application and not being fed with organic fertilizers (manure and dolomite).

This is seen in the field, the plant is rather tight so that it affects the growth of the plant such as the number of branches. In the technology of the way farmers there is competition between individual plants in the population against growing factors, especially light. The denser the population, the greater the competition that occurs so that it will affect the growth rate of plants. At the beginning of growth, there was no competition because there was still enough room for plant growth, but the headings and roots of each plant touched each other and overlapped each other so that competition occurred.

The high number of ICM-1 and ICM-2 filled pods is likely due to the higher the total number of pods, the higher the number of filled pods and the lower the number of hollow pods. The less the total number of pods, the less the number of pods in it. Soybean yields by ICM-1 were 21.9% higher than in the ICM-2 way, and 51.6% higher than the farmer's way (Table 2). The results of this study are in line with the results of the study which reported that integrated crop management (ICM) of soybeans can increase productivity 1.6 times or 62.09% compared to farmer technology. Furthermore, soybean yields with tidal land soybean cultivation technology obtained 14.3% of cooperative farmers reached >2.5 t ha-1, 75% of cooperative farmers the results ranged from 2.0-2.5 t ha-1, and 10.7% of farmers the yield ranged from 1.5-2.0 t ha-1.

The higher yield of ICM-1 soybeans compared to the ICM-2 method and the farmer's way is supported by yield components such as a larger number of branches, and a greater number of filled pods per plant, thus it appears that the growth gap of plants and yield components is different, so the soybean yield is also different (Table 2). The high difference in yield is influenced by tillage, the use of quality seeds, the method and dosage of fertilization in addition to the use of manure and dolomite. Taufiq et al. (2011) reported soybean yields increased at Phoska fertilization doses of 100 kg ha-1, dolomite 750 kg ha-1 and organic fertilizers 1 t ha-1. Furthermore, (Hendrawati *et al.*, 2021) with fertilization of 37.5-45.0 kg N ha-1 and 45-70 kg of P2O5 ha-1 obtained soybean yields of 2.0-2.5 t ha-1. Dolomite administration effectively increases the soil pH of tidal marshlands (Ghulamahdi, Welly and Sagala, 2018), increase levels of elements K, Ca, and Mg, and lower Fe.

Table 2. Soybean growth and yield in the study of soybean cultivation technology in Bandar Jaya

Village, Rantau Rasau District, Tanjung Jabung Timur-Jambi Regency, Indonesia 2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Plant height (cm) | Soybean Cultivation Technology | Average | ICM-1 | ICM-2 |
|  | ICM-1 | 77,10 | - |  |
|  | ICM-2 | 75,50 | tn | - |
|  | Farmers way | 65,50 | \*\* | \*\* |
| Numbers of branches | Soybean Cultivation Technology | Average | ICM-1 | ICM-2 |
|  | ICM-1 | 4,30 | - |  |
|  | ICM-2 | 3,40 | \*\* | - |
|  | Farmers way | 2,30 | \*\* | \*\* |
| Number of filled pods/plants | Soybean Cultivation Technology | Average | ICM-1 | ICM-2 |
|  | ICM-1 | 58,80 | - |  |
|  | ICM-2 | 51,00 | \*\* | - |
|  | Farmers way | 43,30 | \*\* | \*\* |
| Number of empty pods/plants | Soybean Cultivation Technology | Average | ICM-1 | ICM-2 |
|  | ICM 1 | 0,50 | - |  |
|  | ICM 2 | 1,20 | \*\* | - |
|  | Farmers way | 5,60 | \*\* | \*\* |
| Production t ha-1 | Soybean Cultivation Technology | Average | ICM-1 | ICM-2 |
|  | ICM-1 | 2,69 | - |  |
|  | ICM-2 | 2,10 | \*\* | - |
|  | Farmers way | 1,30 | \*\* | \*\* |

Description: \*\* = very significantly different (Probability < 0.01)

ns = not significantly different (Probability > 0.05)

**Farm Fee structure and Revenue.**

The cost structure of soybean farming with farmer technology (Table 3), shows that the largest proportion of costs is labor reaching 67.1 % followed by the purchase of seeds, herbicides, Insecticides, urea fertilizers, and SP 36. When viewed from the total receipts, the allocation for financing soybean farming technology farmers costs around 50.1% of the total farm revenues, meaning that farmers receive compensation from their farming business around 49.9% or around 4,525,000 IDR, with a three-month soybean planting period meaning that farmers receive an average income of 1,508,333 IDR each month.

The cost structure and allocation of soybean farming revenues with ICM-2 technology (Table 3), shows that the largest proportion of costs is for labor wages which reach 58.4% of the total cost, followed by costs for the purchase of manure, urea, SP 36, and KCl about 23.6% of the total cost. The proportion of seed purchases is relatively smaller than the proportion for seed purchases in farmer technology, namely 7.9% and 13.1%. As for the purchase of herbicides, it is relatively larger than the technology of farmers. Judging from the total revenue, the allocation used to finance farming is relatively lower, namely 51.5%, meaning that farmers receive labor rewards from soybean farming businesses around 48.5%. ICM-2 soybean farmers receive a reward for their farming of Rp 7,192,500 with a planting period of 3 months or 2,397,500 IDR each month. From the description above, it can be seen that the ICM-2 soybean technology provides relatively greater advantages than farmers' technology.

The cost structure and allocation of soybean farming revenues with ICM -1 technology (Table 3), shows that the largest proportion of costs is for labor wages which reach 64.9 % of the total cost, followed by costs for the purchase of urea, SP 36, KCl, manure and dolomite fertilizers about 19.9 % of the total cost. The proportion of seed purchases is relatively smaller than the proportion for seed purchases in farmer technology, namely 6.7% and 13.1%. As for the purchase of herbicides, it is relatively larger than the technology of farmers. Judging from the total revenue, the allocation used to finance farming is relatively lower, namely 47.7%, meaning that farmers receive labor rewards from soybean farming businesses around 52.3%. ICM-1 soybean farmers receive a farm reward of 9,840,000 IDR with a planting period of 3 months or 3,280,000 IDR/month. From the description above, it can be seen that soybean ICM-1 technology provides relatively greater advantages than ICM-2 and farmer technology.

Table 3. The cost structure and receipt of soybean farming in the study of soybean cultivation technology in

Bandar Jaya Village, Rantau Rasau District, Tanjung Jabung Timur-Jambi Regency, Indonesia 2019

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Uraian | ICM-1 | | | ICM-2 | | | Farmer Way | | |
| Total  (IDR) | Proportion to | | Total  (IDR | Proportion to | | Total  (IDR) | Proportion to | |
| Cost  (%) | Income (%) | Cost  (%) | Income (%) | Cost  (%) | Income (%) |
| - Seed | 600.000 | 6,7 | 3,2 | 600.000 | 7,9 | 4,1 | 600.000 | 13,1 | 6,5 |
| - Urea | 130.000 | 1,5 | 0,7 | 130.000 | 1,7 | 0,8 | 130.000 | 2,8 | 1,4 |
| - SP 36 | 260.000 | 2,9 | 1,4 | 260.000 | 3,4 | 1,7 | 130.000 | 2,8 | 1,4 |
| - KCl | 400.000 | 4.4 | 2,1 | 400.000 | 5,3 | 2,7 | - | - | - |
| - Manure | 1.000.000 | 11,1 | 5,3 | 1.000.000 | 13,2 | 6,8 | - | - | - |
| - Herbisida | 400.000 | 4,5 | 2,1 | 400.000 | 5,3 | 2,7 | 400.000 | 8,7 | 4,3 |
| - DMA | 112.000 | 1,2 | 0,6 | 112.000 | 1,5 | 0,6 | - | - | - |
| - Insektisida | 250.000 | 2,8 | 1,3 | 250.000 | 3,3 | 1,6 | 250.000 | 5,5 | 2,7 |
| - Labor | 5.838.000 | 64,9 | 31,0 | 4.425.000 | 58,4 | 30,1 | 3.065.000 | 67,1 | 33,6 |
| - Total cost | 8.990.000 | 100,0 | 47,7 | 7.577.000 | 100,0 | 51,5 | 4.575.000 | 100.0 | 50,3 |
| -Production (kg/ha) | 2.690 |  | - | 2.100 |  | - | 1.300 |  | - |
| - Price (IDR kg-1) | 7.000 |  | - | 7.000 |  | - | 7.000 |  | - |
| - Income (IDR) | 18.830.000 |  | 100,0 | 14.700.000 |  | 100,0 | 9.100.000 |  | 100,0 |
| Advantage (IDR) | 9.840.000 |  |  | 7.192.500 |  |  | 4.525.000 |  |  |

**Economic Analysis**

To see the economic analysis of soybean farming through ICM-1, ICM-2 technology and the way farmers are listed in Table 4. ICM-1 and ICM -2 soybean technology using quality seeds, increasing the type of fertilizer and fertilization method, manure and dolomite as well as spacing in farming is a component that increases farm inputs so as to increase farm business costs. Additional costs in soybean ICM technology are found in the components of purchasing herbicides, urea fertilizers, SP 36, KCl, manure, dolomite and pesticides as well as labor use. Large additional costs occur on labor and the purchase of fertilizers. Additional labor costs are mainly on fertilization and closing of planting pits because the amount of labor use volume is more on soybean ICM technology as well as harvesting and post-harvest. Additional fertilizer costs due to the application of SP 36, KCl, manure and dolomite (organic fertilizers). Farm revenues with the ICM-1 system were 51.7% higher than those of farmers or 21.9% higher than those of the ICM-2 system (Table 4). The higher acceptance of ICM-1 is due to the high productivity compared to the ICM-2 system and the way farmers. Farm income with ICM-1 is 54.0% higher than that of farmers or 27.6% higher than that of ICM-2.

Table 4. Economic analysis per ha on the study of soybean cultivation technology in Bandar Jaya Village,

Tanjung Jabung Timur Regency, Indonesia 2019

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Description | Soybeans Cultivation Technology | | | | | |
| ICM-1 | | ICM-2 | | Farmer way | |
| I. Production facilities  (IDR) | Volume | Value  (IDR) | Volume | Value  (IDR) | Volume | Value  (IDR) |
| - Seed | 40 kg | 600.000 | 40 kg | 600.000 | 40 kg | 600.000 |
| - Urea | 50 kg | 130.000 | 50 kg | 130.000 | 50 kg | 130.000 |
| - SP 36 | 100 kg | 260.000 | 100 kg | 260.000 | 50 kg | 130.000 |
| - KCl | 50 kg | 400.000 | 50 kg | 400.000 | - | - |
| - Manure | 1000 kg | 1.000.000 | 1000 kg | 1.000.000 | - | - |
| - Herbisida | 5 l | 400.000 | 5 l | 400.000 | 5 l | 400.000 |
| - DMA | 1 bottle | 112.000 | 1 bottle | 112.000 | - | - |
| - Insektisida | 2 bottles | 250.000 | 2 bottles | 250.000 | 2 bottles | 250.000 |
| Total |  | 3.152.000 |  | 3.152.000 |  | 1.510.000 |
| II. Labor (IDR) | Labor day | IDR | Labor day | IDR | Labor day | IDR |
| - Tillage | Wholesale | 1.000.000 | - | - | - | - |
| - Grass spray | Wholesale | 280.000 | Wholesale | 280.000 | Wholesale | 280.000 |
| - Plant | Wholesale | 2.000.000 | Wholesale | 2.000.000 | Wholesale | 1.500.000 |
| - Fertilization | 2 WPD \*) | 150.000 | 2 WPD \*) | 150.000 | 1 WPD \*) | 75.000 |
| - Weeding | 3 WPD \*) | 225.000 | 3 WPD \*) | 225.000 | 2 WPD \*) | 150.000 |
| - Pest and deseases control | 4 WPD \*) | 300.000 | 4 WPD \*) | 300.000 | 2 WPD \*) | 150.000 |
| - Harvest and processing | Wholesale | 1.883.000 | Wholesale | 1.470.000 | Wholesale | 910.000 |
| Amount |  | 5.838.000 |  | 4.425.000 |  | 3.065.000 |
| Total I + II |  | 8.990.000 |  | 7.577.000 |  | 4.575.000 |
| III. In come (IDR) |  | |  | |  | |
| a.Result (kg ha-1) | 2.690 | | 2.100 | | 1.300 | |
| b.Result (IDR kg-1) | 7.000 | | 7.000 | | 7.000 | |
| Income (IDR) | 18.830.000 | | 14.700.000 | | 9.100.000 | |
| IV. Income (IDR) | 9.840.000 | | 7.123.000 | | 4.525.000 | |
| R/C | 2,09 | | 1,94 | | 1,99 | |
| MBCR ICM-1 vs farmer way | 2,20 | | | | | |
| MBCR ICM-2 vs farmer way | 1,86 | | | | | |

\*) Working People’s Day

The difference in the amount of receipts and costs of farming affects the R/C ratio. From Table 4 it can be seen that with ICM-1 technology it provides relatively higher R/C compared to ICM-2 and farmer technology. This shows that soybean cultivation technology is economically quite feasible and the feasibility of soybean farming with ICM-1 technology is better than ICM-2 and farmer technology. According to the last activity report, ICM accepts soybean farming 62% more than farmers, and tidal land soybean cultivation method is judged technically and financially feasible with an R/C ratio of 2.02.

MBCR analysis shows that MBCR ICM-1 vs farmer way is higher compared to MBCR ICM-2 vs farmer way (Table 4). According to Malian (2004) that the agricultural business technology studied will attract farmers if intuitively the MBCR value is greater or equal to two. The MBCR value of 2.20 means that this value indicates that each addition of one input unit can increase soybean farming income by 2.20 times.

**Conclusion**

Based on the results of the economic analysis of three packages of soybean cultivation technology, the income of farming with ICM-1 technology is 54.0% higher than that of farmers and 27.6% higher than that of ICM-2 technology. ICM-1 technology of soybean cultivation is feasible to be developed in tidal marshlands of Tanjung Jabung Timur Regency, because with the application of ICM-1 technology soybeans can economically increase farm profits by 9,840,000, IDR ha-1 with an MBCR value of 2.20. For the sustainability of the development of ICM-1 technology, government policy support is needed in terms of agricultural production facilities and price policies, the use of alternative fertilizers and the use of biological agents and seed breeding by farmers. In addition, it still needs guidance and assistance by officers and dissemination of technological innovations, both through information and communication technology and direct dissemination.

**References**

Adi, D. *et al.* (2019) ‘Adoption Determinants of Biofertilizer Technology for Soybean in Rainfed Area Adoption Determinants of Biofertilizer Technology for Soybean in Rainfed Area’. Available at: https://doi.org/10.1088/1755-1315/347/1/012114.

Anapalli, S.S. *et al.* (2022) ‘Investigating soybean (Glycine max L.) responses to irrigation on a large-scale farm in the humid climate of the Mississippi Delta region’, *Agricultural Water Management*, 262(November 2021), p. 107432. Available at: https://doi.org/10.1016/j.agwat.2021.107432.

Asodina, F.A. *et al.* (2020) ‘Are non-market benefits of soybean production significant? An extended economic analysis of smallholder soybean farming in Upper West region of northern Ghana’, *Agriculture and Food Security*, 9(1), pp. 1–13. Available at: https://doi.org/10.1186/s40066-020-00265-7.

Belay, A. (2008) ‘Production and Quality Assurance’, *Fossils*, 1, pp. 1–25.

Caetano, J.M. *et al.* (2018) ‘Geographical patterns in climate and agricultural technology drive soybean productivity in Brazil’, *PLoS ONE*, 13(1), pp. 1–16. Available at: https://doi.org/10.1371/journal.pone.0191273.

Cattelan, A.J. and Dall’Agnol, A. (2018) ‘The rapid soybean growth in Brazil’, *OCL - Oilseeds and fats, Crops and Lipids*, 25(1), pp. 1–12. Available at: https://doi.org/10.1051/ocl/2017058.

Chander, S. *et al.* (2021) ‘Genetic diversity and population structure of soybean lines adapted to sub-saharan africa using single nucleotide polymorphism (Snp) markers’, *Agronomy*, 11(3). Available at: https://doi.org/10.3390/agronomy11030604.

Chen, Y. *et al.* (2015) ‘Rational phosphorus application facilitates the sustainability of the wheat/maize/soybean relay strip intercropping system’, *PLoS ONE*, 10(11), pp. 1–16. Available at: https://doi.org/10.1371/journal.pone.0141725.

Didorenko, S.V. *et al.* (2021) ‘Monitoring quality and yield capacity of soybean varieties during the creation of various ecotypes in Kazakhstan’, *Agrivita*, 43(3), pp. 558–568. Available at: https://doi.org/10.17503/agrivita.v43i3.2799.

FU, Z. dan *et al.* (2019) ‘Effects of maize-soybean relay intercropping on crop nutrient uptake and soil bacterial community’, *Journal of Integrative Agriculture*, 18(9), pp. 2006–2018. Available at: https://doi.org/10.1016/S2095-3119(18)62114-8.

Gawęda, D. *et al.* (2020) ‘Yield and Economic Effectiveness of Soybean Grown Under Different Cropping Systems’, *International Journal of Plant Production*, 14(3), pp. 475–485. Available at: https://doi.org/10.1007/s42106-020-00098-1.

Ghulamahdi, M., Welly, H.D. and Sagala, D. (2018) ‘Nutrient uptake, growth and productivity of soybean cultivars at two water depths under saturated soil culture in tidal swamps’, *Pakistan Journal of Nutrition*, 17(3), pp. 124–130. Available at: https://doi.org/10.3923/pjn.2018.124.130.

Hadi, A., Zahrita and Haris, A. (2020) ‘Effect of Irradiated Rice Varieties on CH4, Population of Bacteria and Fungi in tidal Swamp Soil in Kalimantan’, *IOP Conference Series: Earth and Environmental Science*, 499(1). Available at: https://doi.org/10.1088/1755-1315/499/1/012023.

Hafif, B. and Khaerati (2021) ‘Effect of indigenous cellulolytic fungi enhancement on organic carbon and soybean production on peat soil’, *IOP Conference Series: Earth and Environmental Science*, 749(1). Available at: https://doi.org/10.1088/1755-1315/749/1/012021.

Hasanah, Y., Hanum, H. and Hidayat, A.S. (2019) ‘Chlorophyll content and stomatal density of soybean varieties on technological packages application under dry land conditions’, *IOP Conference Series: Earth and Environmental Science*, 260(1), p. 012165. Available at: https://doi.org/10.1088/1755-1315/260/1/012165.

Hendrawati, T.Y. *et al.* (2021) ‘Effects and characterization of different soybean varieties in yield and organoleptic properties of tofu’, *Results in Engineering*, 11(June). Available at: https://doi.org/10.1016/j.rineng.2021.100238.

Jumakir, J. and Abdullah, T. (2009) ‘Kajian teknologi budidaya dan kelayakan ekonomi usahatani kedelai dengan pendekatan pengelolaan tanaman terpadu di lahan pasang surut jambi’, 13(1), pp. 1–10.

Karges, K. *et al.* (2022) ‘Agro-economic prospects for expanding soybean production beyond its current northerly limit in Europe’, *European Journal of Agronomy*, 133(November 2021), p. 126415. Available at: https://doi.org/10.1016/j.eja.2021.126415.

Karyawati, A.S. and Puspitaningrum, E.S.V. (2021) ‘Correlation and path analysis for agronomic traits contributing to yield in 30 genotypes of soybean’, *Biodiversitas*, 22(3), pp. 1146–1151. Available at: https://doi.org/10.13057/biodiv/d220309.

Krisdiana, R. *et al.* (2021) ‘Financial feasibility and competitiveness levels of soybean varieties in rice-based cropping system of Indonesia’, *Sustainability (Switzerland)*, 13(15). Available at: https://doi.org/10.3390/su13158334.

Latawiec, A.E. *et al.* (2021) ‘Economic Analysis of Biochar Use in Soybean Production in Poland’, *Agronomy*, 11(11), p. 2108. Available at: https://doi.org/10.3390/agronomy11112108.

Liu, D. *et al.* (2020) ‘Effects of corn straw biochar application on soybean growth and alkaline soil properties’, *BioResources*, 15(1), pp. 1463–1481. Available at: https://doi.org/10.15376/biores.15.1.1463-1481.

Mahama, A. *et al.* (2020) ‘Heliyon Modelling adoption intensity of improved soybean production technologies in Ghana - a Generalized Poisson approach’, *Heliyon*, 6(June 2019), p. e03543. Available at: https://doi.org/10.1016/j.heliyon.2020.e03543.

Matthews, M.L. *et al.* (2022) ‘Soybean-BioCro: A semi-mechanistic model of soybean growth’, *In Silico Plants*, 4(1), pp. 1–11. Available at: https://doi.org/10.1093/insilicoplants/diab032.

Meithasari, D., Endriani and Rumbaina, D. (2020) ‘Levels of soybean pest attacks on study of soya plant technology package in acid dry land soils in South Lampung’, *IOP Conference Series: Earth and Environmental Science*, 484(1). Available at: https://doi.org/10.1088/1755-1315/484/1/012112.

Meseldžija, M. *et al.* (2020) ‘Economic feasibility of chemical weed control in soybean production in Serbia’, *Agronomy*, 10(2), pp. 1–12. Available at: https://doi.org/10.3390/agronomy10020291.

Mubeen, K. *et al.* (2021) ‘The impact of horse purslane (Trianthema portulacastrum L.) infestation on soybean [Glycine max (L.) Merrill] productivity in northern irrigated plains of Pakistan’, *PLoS ONE*, 16(9 September), pp. 1–14. Available at: https://doi.org/10.1371/journal.pone.0257083.

Muniz, M.P. *et al.* (2022) ‘Soybean yield in integrated crop – livestock system in comparison to soybean – maize succession system’.

Nget, R. *et al.* (2021) ‘Overview of farmers’ perceptions of current status and constraints to soybean production in Ratanakiri province of Cambodia’, *Sustainability (Switzerland)*, 13(8). Available at: https://doi.org/10.3390/su13084433.

Pekša, K. *et al.* (2021) ‘Productivity of different soybean cultivars depending on meteorological conditions and growing manner in Latgale 2018–2020’, *Vide. Tehnologija. Resursi - Environment, Technology, Resources*, 1, pp. 206–212. Available at: https://doi.org/10.17770/etr2021vol1.6636.

Radocaj, D. *et al.* (2020) ‘Delineation of soil texture suitability zones for soybean cultivation: A case study in continental Croatia’, *Agronomy*, 10(6). Available at: https://doi.org/10.3390/agronomy10060823.

Ratmini, N.P.S., Herwenita and Irsan, F. (2021) ‘Climate change mitigation through superior varieties use to increase rice production in tidal swamp land’, *IOP Conference Series: Earth and Environmental Science*, 824(1). Available at: https://doi.org/10.1088/1755-1315/824/1/012019.

Salama, H.S.A. and Abdel-Moneim, M.H. (2021) ‘Maximizing land use efficiency and productivity of soybean and fodder maize intercrops through manipulating sowing schedule and maize harvest regime’, *Agronomy*, 11(5). Available at: https://doi.org/10.3390/agronomy11050863.

Slameto, Meidaliyantisyah and Wibawa, W. (2021) ‘Study of “ Turiman Jale 2-7” system production in acid dry agroecosystem in Lampung Region’, *IOP Conference Series: Earth and Environmental Science*, 807(4). Available at: https://doi.org/10.1088/1755-1315/807/4/042002.

Sobko, O. *et al.* (2020) ‘Environmental effects on soybean (Glycine max (l.) merr) production in central and south germany’, *Agronomy*, 10(12), pp. 1–14. Available at: https://doi.org/10.3390/agronomy10121847.

Sohn, S.I. *et al.* (2021) ‘Dynamics of bacterial community structure in the Rhizosphere and root nodule of Soybean: Impacts of growth stages and varieties’, *International Journal of Molecular Sciences*, 22(11). Available at: https://doi.org/10.3390/ijms22115577.

Surahman, M. *et al.* (2018) ‘Five steps toward the Indonesian soybean self-sufficiency’, *IOP Conference Series: Earth and Environmental Science*, 196(1). Available at: https://doi.org/10.1088/1755-1315/196/1/012044.

Tantawizal *et al.* (2021) ‘Development stages of soybean varieties against pod sucking pest Riptortus linearis F. (Hemiptera: Alydidae) under two different cultivation technologies’, *IOP Conference Series: Earth and Environmental Science*, 913(1). Available at: https://doi.org/10.1088/1755-1315/913/1/012012.

Tilba, V.A., Makhonin, V.L. and Zelentsov, S. V. (2021) ‘The effect of native strains of nodule bacteria on the development of symbiotic apparatus and on the productivity of new soybean cultivars’, *IOP Conference Series: Earth and Environmental Science*, 650(1). Available at: https://doi.org/10.1088/1755-1315/650/1/012042.

Toloi, M.N.V. *et al.* (2021) ‘Development indicators and soybean production in Brazil’, *Agriculture (Switzerland)*, 11(11), pp. 1–15. Available at: https://doi.org/10.3390/agriculture11111164.

Tolokonnikov, V. V. *et al.* (2021) ‘Agromeliorative methods of cultivation of a new variety of soybeans Volgogradka 2 under irrigation conditions’, *IOP Conference Series: Earth and Environmental Science*, 659(1). Available at: https://doi.org/10.1088/1755-1315/659/1/012072.

Wijanarko, A., Taufiq, A. and Harnowo, D. (2016) ‘J OURNAL OF D EGRADED AND M INING L ANDS M ANAGEMENT Effect of liming , manure , and NPK fertilizer application on growth and yield performance of soybean in swamp land’, 3(2), pp. 527–533. Available at: https://doi.org/10.15243/jdmlm.2016.032.527.

Yang, F. *et al.* (2014) ‘Growth of soybean seedlings in relay strip intercropping systems in relation to light quantity and red: Far-red ratio’, *Field Crops Research*, 155, pp. 245–253. Available at: https://doi.org/10.1016/j.fcr.2013.08.011.

Zhao, X. *et al.* (2018) ‘Functional, nutritional and flavor characteristic of soybean proteins obtained through reverse micelles’, *Food Hydrocolloids*, 74, pp. 358–366. Available at: https://doi.org/10.1016/j.foodhyd.2017.08.024.

ZHU, Q. *et al.* (2019) ‘Effect of biochar on grain yield and leaf photosynthetic physiology of soybean cultivars with different phosphorus efficiencies’, *Journal of Integrative Agriculture*, 18(10), pp. 2242–2254. Available at: https://doi.org/10.1016/S2095-3119(19)62563-3.