Technology innovation implementation for increasing rice cropping index on swampland of Riau Province

A Fahri, R Yusuf, R S Anggraini and Salwati

Riau Assessment Institute for Agriculture Technology, Riau, Indonesia
E-mail: anisfahri@gmail.com

Abstract. Swamp land will be the foundation of future food security, because irrigated paddy fields are very vulnerable to the land transfer functions, as happened on the Island of Java. Swampland has considerable potential to develop into food-based agriculture land in support of national food security. Swampland is divided into two types, namely: 1) tidal swamp and 2) waterlogged swamp. Land reclamation from tidal swamps for rice field in Riau province, covering an area of 80,868 ha, with low productivity at around 3.5 to 4.5 t ha\(^{-1}\) and average cropping index (CI) 100. This study aims to examine the application of technological innovation to improvement of rice cropping index. Referring to rice potential planting calendar of Riau Province, the planting season on rainy season 2019/2020 (October 2019 - March 2020) and the average rice cropping index of dry season 2020 were 171.49 percent. The application of Jarwo Super Planting Calendar of Rice crop productivity reached 5.73 t ha\(^{-1}\).

1. Introduction
Demand for food is notably rice expected to increase over the years. Thus, encouraging the Indonesian government to develop agricultural land into sub-optimal area that is potentially wide provided in Indonesia. In the future, sub-optimal land estimated will play a significant role in agricultural development in Indonesia. Many researches showed that swampland is quite potential for agriculture, both for food crops, plantations, horticulture, and livestock business. Also, swamps will become strategic and crucial for agricultural development as well as support food security and agribusiness [1].

Agricultural resource utilization needs to be optimized through the improvement of infrastructure and human resource capacity, as well as the application of technological innovations produced by many research institutions. One of the available land resources that has not been used optimally is tidal swampland. Besides, a tidal swamp is one type of agroecology that has great potential for agricultural development, particularly food crops [2].

The decline in land area for food crops due to the land function conversion and low land productivity in Riau Province remains a strategic issue for now a days and in the future. Productive rice fields deterioration, land fertility decline, and sloping down of rice productivity require restorative act in order to increase the existing rice fields productivity, increase rice cropping index, and find other potential lands including swamplands.

Farming in tidal swamps generally has a low yield due to the low soil fertility, pyrite compounds content, soil acidity, intrusion from seawater, and in some parts covered by a layer of peat. Plant growth in tidal land faces various obstacles such as soil acidity, nutrient toxicity and deficiencies, salinity, and
oversupply or lack of water. Rice is the commodity that is mostly cultivated by farmers, with simple cultivation techniques, farmers using local varieties, and low doses of incomplete fertilization [3].

Tidal swamp in Riau Province covers an area of 34,766 ha. There is the potential for agricultural development in Indragiri Hilir, Indragiri Hulu, Pelalawan, Rokan Hilir and Siak. The rice productivity of Riau province is about 3.5 to 4.5 t ha\(^{-1}\) and the average Cropping Index (CI) is 100, planting generally occurs once a year [4]. The potential of tidal land in Riau is high. However, swamp land utilization for rice production is still limited. The various inherent characteristics of this land become obstacles for swampland development as a national food barn. Various studies have shown that the soil fertility level in tidal land is low [5, 6].

Increasing rice production can be achieved through increasing the quantity of planting, expanding the area and increasing the cropping index (CI). While increasing productivity through the use of new superior variety seeds, improving irrigation channel, fertilizing according to plant nutrient status, maintaining plants (controlling plant pests) and reducing rice yield losses during the harvesting time. The increase of rice production reached 5 to 6 t ha\(^{-1}\) through the introduction of rice technology such as superior seeds, fertilization, amelioration, pest control [7].

An effective and efficient approach to increase national rice production by sustainable agricultural practice through the correct selection of technology components by taking into account the conditions of biotic environment, abiotic environment and optimal land management by farmers including the use of existing local residues and resources [8]. This paper aims to examine the application of agricultural technology innovation to increase the productivity of swampland in Riau Province.

2. Materials and methods
The methods used in this paper included the following:

- Desktop research to review existing technology innovation at farm gate, focusing on the rice production system, planting calendar, government policies, issues, and constraints;
- Fieldwork based on stakeholder consultations and informant interviews to understand technology innovation implementation associated with rice cropping index improvement; and
- Collection and analysis of secondary data.

The literature review focused more on integrated planting calendar information systems. Fieldwork was conducted in January to December 2019. Informant interviewed included: farmer group leaders, rice farmers, and extension officers. Meetings and consultations were also held with government agencies (Dinas) to understand the policy settings, as well as their views on, experiences with technology innovation implementation and rice cropping index.

3. Results and discussion

3.1. Potential and constraints of food crop development on swampland
Swamplands have significant potential to signify improve into a food-based agricultural estate for supporting national food security. Thus, the swampland area covering 33.4 million ha area spread across 17 provinces, those areas expected to become an economy and modernization driving force for the local region. Palembang, Banjarmasin, Palangkaraya, Pontianak, Pekanbaru, and Jambi are big cities that grow and develop on swampland agro-ecosystems. Swampland, which covers an area of about 34 million ha, consists of 20.707 million ha of tidal swamps and 13.296 million ha of waterlogged swamps. Yet, around 5.0 million ha of the swampland had been reclaimed for agriculture purposes in Indonesia. The reclaimed tidal land in Riau Province comprises 80,868 ha [2]. Wetland potentials for agricultural land in the period ahead, largest is on the three islands, namely Sumatra, Kalimantan, Papua, and small part in Sulawesi [9]. In Sumatra, swamplands mostly cover the large area of lowland along the coast of the east, especially in the provinces of Riau, South Sumatra, and Jambi, slightly in North Sumatra and Lampung. On the west coast, swamps occupy narrow coastal plains, especially in the Provinces of Aceh.
(around Meulaboh and Tapaktuan), West Sumatra (Rawa Lunang, Pesisir Selatan District), and Bengkulu (south of Bengkulu City).

In Borneo, the distributions of swampland are dominantly in the plains of lower along the coast of the western province of West Kalimantan; south coast of Central Kalimantan Province, minor in South Kalimantan; and the east and northeast coast of East Kalimantan Province. A large expense of swampy wetlands is found in the upstream Kapuas River, next to west Putussibau, West Kalimantan, and around the lakes of Semayang and Melintang, in Kotabangun, in the watershed of the middle Mahakam river, East Kalimantan.

In Sulawesi, the distribution of swamps is relatively narrow and limited to the coastal plains. Extensive wetlands are found on the southwest coast of Palu Municipality, Mamuju and around the Gulf of Bone, along the northeast coast of Palopo, and a little on the south coast district of Toli-Toli around the Gulf of Tomini.

Various research results indicate that swamps have the prospect of being developed into agricultural land to support the increase of agricultural food production. However, it needs to be realized that besides having good prospects, the development of tidal swampland for agriculture also has various obstacles, both in biophysical, socio-economic and institutional aspects. The tidal land is a fragile marginal land, with unstable characteristics, change of the environment. Land miss management from the beginning will have a negative impact, and to renew it requires a lot of time, or even cannot be reclaimed at all.

In the last decades, swampland has been widely discussed about the efforts to provide food and energy, which are often confronted with greenhouse gas (GHG) emissions as a trigger for climate change. Swamp rice farming in Riau Province is still facing a problem of low productivity, this is due to the lack of development in production technology innovation. The rice productivity of Riau Province is around 3.5 to 4.5 tons ha\(^{-1}\) and the average planting index (PI) is 100, planting is generally only once a year. Opportunities to increase productivity are still open with the support of land resources and a suitable climate for each rice plant.

Efforts to increase land productivity and at the same time to increase the welfare of farmers, need a strategy/program that is supported by appropriate technology leading to improved farm management through increasing farm productivity and efficiency, as well as maintaining soil fertility through soil and water conservation measures.

### 3.2. Agricultural technology implementation

Farming technology developed in tidal fields is requisite site-specific technology that is adaptable to biophysical and social institutional conditions. The technology takes into consideration of some factors such as climate, land, water management, agricultural cultivation techniques, and socio economic supporting system. However, due to the limitations of labour, capital, and less productive land, thus farmers finally plant rice once a year with planting pattern paddy-fallow. Some agricultural technologies disseminated to the farmers are as follows.

#### 3.2.1. Integrated planting calendar information system.

Climate change marked by changes in rainfall patterns and distribution [10], increased air temperatures [11], and rise the sea level has direct and indirect impacts on agricultural areas [12]. One of the implications of climate change is a shift in the beginning and end of the planting season which negatively impacts cropping patterns and crop productivity, particularly seasonal crops. Rununuwu et al. [13] specifically states that agricultural production in Indonesia is strongly influenced by rainfall, both inter-seasonal and inter-year variations, as a result of the dynamic Australia-Asia and El Nino-Southern Oscillation (ENSO) monsoons.

To guide farmers in adjusting planting times and patterns, the Indonesian Agency For Agricultural Research and Development (IAARD), Indonesian Ministry of Agriculture, since 2007 has compiled information on rice planting calendars for every sub-district all over Indonesia in the form of an atlas. The Map of Food Cropping Calendar at a scale of 1: 250,000 has been made for the islands: Java [14, 15], Sumatera [16].
In line with MOA No. 45/2011, the Indonesian Agency for Agricultural Research and Development has developed the Integrated Planting Calendar Information System (here in after abbreviated as SI Katam Integrated), which becomes a reference for policy makers in the preparation of district-scale food crop management plans [17].

Based on the Recapitulation of Potential Rice Planting Calendar in Riau Province, the rice cropping index in Riau province in rainy season 2019/2020 (October 2019 to March 2020) and dry season 2020 obtained – average cropping index amounted to 171.49 (table 1). Along with the increase of cropping index and the use of fertilizers as recommended, it is hoped that an increase in yield will follow.

**Table 1. Rice planting calendar in Riau Province, rain season 2019 and dry season 2020.**

| No. | Districts     | Land Area (ha) | Estimated Planting Area (ha) | Planting Index (%) |
|-----|---------------|----------------|------------------------------|--------------------|
|     |               | Tidal | Waterlogged | Others | Total | RS 2019 | DS 2020 | Total | Existing 2019 |               |
| 1   | Indragiri Hilir | 25,491 | 0            | 0     | 25,491 | 16,545 | 15,089 | 31,634 | 19,159 | 120            |
| 2   | Indragiri Hulu  | 964   | 228          | 1,574 | 2,766  | 3,166  | 2,300  | 5,466  | 1,917  | 174            |
| 3   | Pelalawan      | 6,419 | 100          | 617   | 7,136  | 5,110  | 7,094  | 12,204 | 5,064  | 103            |
| 4   | Rokan Hilir    | 736   | 625          | 0     | 12,071 | 11,100 | 16,064 | 27,164 | 9,422  | 143            |
| 5   | Siak           | 0     | 128          | 3,778 | 3,906  | 4,442  | 7,187  | 11,629 | 7,741  | 136            |
| Total |             | 33,610 | 1,156       | 19,834 | 51,370 | 40,363 | 47,734 | 88,097 | 43,403 | 171.49        |

Source: Integrated rice planting calendar of Riau Province (DS April - September 2020)

**3.2.2. Land and water management technology.** Wetlands are one of the wetland ecosystems (wetland) located between the regions and the mainland system (terrestrial) in deep water (aquatic). This area is characterized by a shallow or thin water level. It is called swampland if it fulfills the following 4 (four) main elements, namely: (1) water-saturated until it is stagnant continuously or periodically which causes an anaerobic atmosphere, (2) sloping topography, flat to concave, (3) mineral sediment (due to erosion carried by river flow) and or peat (due to piles of residual vegetation), and (4) vegetation is naturally overgrown [18].

Based on the nature of the soil and its constraints in agricultural development, swamps are divided into four land typologies, namely: (1) potential land, (2) acid sulphate land, (3) peat land, (4) and saline land. It is called a potential land because it has lighter constraints compared to acid sulphate land or peatlands, including moderate soil acidity (soil pH >4.0 to 4.5), the pyrite layer is >100 cm deep, aluminum and iron content are low. It is called acid sulphate land because it has heavier constraints because pyrite is at a depth of 50 to 100 cm and partly at a depth of >100 cm, the soil pH is 4.0 to 4.5 when oxidized it reduces the pH to <3.5. In addition, this acid sulphate land typology also has high levels of aluminum and iron. Based on the depth of pyrite and the intensity level of oxidation that occurs, acid sulfate land is divided into two typologies, namely: (1) potential acid sulphate land and (2) actual acid sulphate land. Meanwhile, it is called peatland because of the presence of a peat layer in the top layer >50 cm thick with >20% organic matter content.

Based on its thickness, peatlands are divided into four land typologies, namely: shallow peat (if the thickness of the peat is >50 to 100 cm), medium peat (peat thickness 101 to 200 cm), deep peat (peat thickness 201 to 300 cm), and very deep peat (peat thickness >300 cm). Peatland has different characteristics from other typologies, including peat layer with bulk density <0.1 g cm$^{-3}$ so that the carrying capacity of the land is very low. Moreover, micronutrient deficiency especially Cu and Zn also occur in peatland. As for the so-called saline land because it has constraints in the form of salinity due to sea water intrusion and influence and it generally has sandy texture because it is on the coastal plain [2].
In the National Meeting of Swampland Agricultural Development held by the Food Crops Research and Development Center in 1992 in Cisarua, Bogor, it was agreed that swamps are divided into 2 (two) swamp typologies, namely: (1) tidal swamps and (2) waterlogged swamps. In the division above the coastal swamp is classified into the tidal swamp land.

Tidal swamplands are classified as swamp areas that are influenced by the presence of spring tide and neap tide from rivers or seas, either directly or indirectly. Based on the effect of tidal overflow, especially during the rainy season, the tidal swamp area is divided into 4 (four) overflow (hydro-topography) types, namely types A, B, C, and D. This grouping is important, especially for the direction of land use and arrangement as well as determining management systems, water and cropping patterns.

Overflow Type A: tidal area which always gets tidal overflow, both single (full moon) and double tide (bandages), and experiences drainage on a daily basis. The area of this type includes the coast and along the river banks.

Overflow Type B: the intertidal zone that gets overflow only when a single tide (full moon), under poor arrangement on a daily basis. The area of this type covers an inland area <50-100 km from the river bank.

Overflow Type C: tidal zone which permanently does not get tidal overflow. The effect of tidal swings is obtained only through seepage and has a groundwater level at a depth of <50 cm from the soil surface.

Overflow Type D: the intertidal zone that is not influenced at all tide swings and poor arrangement are limited. The ground water level reaches a depth of >50 cm from the soil surface.

Single tide (full moon) only lasts at optimal tide height. It can overflow 3 to 4 days and lasts 3 to 4 hours, especially on land with type B. Double tides can only overflow during the rainy season. In the dry season, double tides cannot overflow the land because the water discharge is less or decreasing. Tidal land suitable for the development of rice plants is an area that has a type of standing water A, B, and C with a surjan and overlay system. The cropping pattern with the arrangement of paddy fields in the overflow type A is paddy. While the cropping pattern with the arrangement of paddy fields or surjan in overflow type B is paddy-rice and paddy-crops/horticulture (table 2).

| Table 2. Reference land arrangement for each land typology and water overflow type in tidal land. |
|----------------------------------|-----------------|----------------|-----------------|-----------------|
| Land Typology                   | Overflow type   | A              | B       | C              | D              |
| Potential                       | Rice fields     | Rice fields   | /       | Rice fields / surjan / moor | Rice fields / moor / gardens |
| Sulfate acid                    | Rice fields     | Rice fields   | /       | Rice fields / surjan / moor | Rice fields / moor / gardens |
| Peat                            | Rice fields     | Rice fields   | /       | Rice fields / surjan / moor | Rice fields / moor / gardens |
| Shallow Peat                    | Rice fields     | Rice fields   | /       | Rice fields / surjan / moor | Rice fields / moor / gardens |
| Medium Peat                     | Rice fields     | Conservation  | Field / Plantation | Plantation |
| Deep Peat                       | Rice fields     | Conservation  | Field / Plantation | Plantation |
| Costal                          | Rice fields / ponds | Rice fields / ponds | -           | -           |

Sources; Widjaya Adhi [19].
In overflow type A land which always overflows with high tide is designated as paddy field, while land of type B overflow which only overflows with high tide becomes a rice field or surjan. Lands of overflow type C are not overflowed by ground water table is soil shallow (<45 cm for potential lands, <15 cm for the land of acid sulfate, and <30 cm for shallow peatlands) used for rainfed/dry land or formed surjan gradually. The land of overflow type D is designated as dry land/plantation. Shallow peatlands are arranged as dry land for horticultural crops, plantations or industrial plants, while maintaining water management so that drying processes do not occur. Deep peat must be used for conservation area. Water management activities cover macro and micro water systems. Macro water system that includes the primary channel, secondary, and tertiary, becomes the responsibility of the Directorate General of Irrigation. Network of micro water management at farm level is the responsibility of farmers. Water management is done by regulating the water system in accordance with the typology of the land and the type of water overflow and adjusted to the needs of plants.

3.2.3. Innovation technology. The objective initial tidal land reclamation aimed to support the transmigration program related to cropping patterns. The land is divided into the yards of houses and farm land 1 and farm land 2. Farm land 1 is originally intended for food crops such as rice, corn and soybeans, farm land 2 is for plantation crops and house yard areas are planted with perennial crops, including coffee, rubber and dominantly coconuts.

Land preparation with tidal land cultivation is needed in addition to improving land conditions to be more uniform and even with the presence of overburden and silting as well as to accelerate the process of washing out toxic materials and mixing amelioration and fertilizer materials with the soil [19]. Soil cultivation that gives good results in terms of physical land and crop yields is by plowing or plowing followed by rotary combined with herbicides. If the soil is loose or muddy and evenly found generally on peat land with type A and B overflows, intensive tillage is not necessary but is replaced with minimum or no tillage (TOT) combined with the use of herbicides. This shows that the tidal area for tillage depends on the land conditions. Although tillage is necessary, it does not have to be done every season, because tillage is done between two planting seasons not reducing crop yields.

The recommended use of rice or hybrid VUB is predicted to be around 20% higher than that of ordinary high yielding varieties. The results of the study using the legowo row planting system and new high yielding varieties in the tidal lowland agro-ecosystem of Kuala Cenaku Village, Kuala Cenaku District, Indragiri Hulu Regency, Riau Province on April to September 2016 produced 5.73 ha\(^{-1}\) higher GKP compared to that of the tile planting system, namely 5.25 t ha\(^{-1}\) GKP. Then the superior variety of Inpara 9, which is adaptive to swamps, produced 5.91 t ha\(^{-1}\) of GKP [20].

The increase in the cropping index is carried out in an effort to anticipate the season by using the ratun or salibu system. Ratun or salibu is a plant that grows from the stump left over at harvest time. The difference between the two is in the treatment of crop residual stumps. In the ratun system, there is no more stump cutting after harvest. In the calibu system, the stump is left for 7 days and after the shoots begin to grow, the stump is cut as low as 3 cm from the soil surface. Thus there is a difference between the ratun and the cross u, namely the cutting height and the cutting intensity of the stem.

Cultivating salibu rice on tidal inundated land did not produce results, while in type C land where the water could be regulated, the P1D-KK-A26, P1D-KK-A48b, and P5E-KK-A5 lines gave yields of more than 4 t ha\(^{-1}\) MPD. Ratun rice cultivation can be done on inundated land or where the water can be regulated. The lines P1F-B-A15, P1D-KK-A26, P1D-KK-A45, P1D-KK-A48b, P1D-KK-A67, and P5E-KK-A5 can be cultivated in a row or a thousand. Efforts to mitigate the narrowing of the growing season with step aside cultivation techniques can be carried out on dry or inundated tidal lands, while the salibu technique is good implemented on land that is not always flooded with salibu and is carried out in areas that are not always inundated [21].

Provision of ameliorant or soil amendment and fertilizer is an important factor to improve soil conditions and increase land productivity. This material can be in the form of lime or dolomite or organic matter or husk ash and sawdust. Recommendations for the use of fertilizers, if no information on soil nutrient status, the dosage of fertilizer can refer to PHSL fertilizer recommendations or MOA.
No. 40/2007 and its revisions or other references recommended by the local Dinas/Bakorluh/BPTP. Information on fertilizer recommendations in the revised MOA No. 40/2007 provides the option of using single fertilizers or compound NPK fertilizers in combination with organic fertilizers.

From a series of research activities on nutrient management and fertilization, the optimum dosage for rice plants can be synthesized as shown in table 3. The combination is in line with the ISDP assessment results in various tidal locations of South Sumatra, Riau, Jambi and West Kalimantan [1].

### Table 3. Dosage of fertilizers and ameliorant for rice plants in tidal fields.

| Type of Fertilizer | Potential land | Acid sulfate soils | Peatlands |
|--------------------|----------------|--------------------|-----------|
|                    | Potential      |                    |           |
| N or urea          | 45-90 = 100-200| 67.5-135 = 150-300 | 45 = 100  |
| P2O5 or SP36       | 22.5-45 = 60-120| 45.0-70 = 120-180  | 60 = 160  |
| K2O or KCl         | 50 = 100       | 45.0-70 = 90-150   | 50 = 100  |
| CuSO4 or terusi    | -              | -                  | 5         |
| ZnSO4              | -              | -                  | 6         |
| Lime or dolomite   | -              | 1,000-3,000        | 1,000-2,000|

Source: Alihamsyah et al [1]

The ability of rice plants to produce unhulled rice is strongly influenced by the growing environment. The more fertile the soil becomes the growing medium for rice plants, the higher the productivity obtained [5, 22]. Research by Masganti et al. [21] reported that the productivity of the Inpara-5 variety cultivated in tidal fields for typology B was influenced by the dose of rice straw compost, the dose of P fertilizer, and their interactions. P fertilization causes the productivity of cultivated rice to increase. Applying P to P-deficient soils will increase rice productivity [23]. Besides, the supply of P derived from TSP fertilizer, P also directly comes from rice straw compost [24, 25].

Another contribution of rice straw compost which indirectly affects the availability of P is the decrease in the solubility of Al and Fe which usually bind P, so that P availability is better [24]. Although P fertilization can increase rice productivity in tidal fields. However, giving P that exceeds the dose of 60 kg P2O5 ha\(^{-1}\) has decreased productivity. Therefore, further research is needed to determine the optimal P dose with narrower intervals in the dose range of 60 kg P2O5 ha\(^{-1}\).

By providing rice straw compost and P fertilizer, P fertilizer can be saved by 30 kg P2O5 ha\(^{-1}\). This figure is really meaningful in the context of saving P fertilizer input. This certainly causes the income of farmers to increase and the government burden for P fertilizer subsidies to decrease. As with P fertilization, the provision of organic rice straw compost increases rice productivity in tidal fields. This is because rice straw compost is able to increase the availability of P, K, Ca and Mg nutrients in the soil. Moreover, the use of rice straw compost not only directly increases the availability of good nutrients because it contains nutrients. However, it is also able to improve soil physical properties which are favorable for plant growth. Improvement of soil physical properties due to the provision of rice straw compost supports better plant root development, so that it can take up more nutrients. In addition, rice straw compost also affects the development of microorganisms in the soil, thereby supporting chemical reactions in the soil that benefit plants. [24, 25].

### 3.2.4. Integrated pest management

Basically, control is carried out by referring to an integrated pest management strategy (IPM), namely through the use of resistant varieties and natural enemies, good cultivation techniques and environmental sanitation. The use of chemical pesticides is done as a last resort. Strategies and integrated methods of controlling rat pests in tidal fields are presented in table 4. The rat pest control strategy is based on a combination and control measures based on the stage of rice plants in the field. For the success of controlling pests and diseases, the support of farmers and officials is required as well as adequate supporting facilities and infrastructure.
Table 4. Strategies and methods of controlling rodents in tidal fields.

| Stadia          | Traditional Method (Gropyokan) | Bait | Fumigation | SPP  | Trap |
|------------------|--------------------------------|------|------------|------|------|
| Rice             | Poisonous                      | Bamboo |
| Fallow           | *                              |     |            |      |      |
| Nursery          | *                              |     |            |      |      |
| Active tillers   | *                              |     |            |      |      |
| Pregnant         | *                              |     |            |      |      |
| Starting         |                                |     |            |      |      |
| Harvest          |                                |     |            |      |      |

SPP : Trap fence system for 1 ha with 40 fruits for 20 ha of rice crops

4. Conclusions

Tidal swampland in Riau Province has great potential and prospects for agricultural development, especially in supporting national food security. Increasing the cropping index to increase production is carried out using technological innovation and adapting to the season using the planting calendar information system. Refer to the Summary of Rice Planting Calendar Potential Riau Province I Index. This crop planting season MH 2019/2020 (October 2019-March 2020) and MK 2020 obtained rice cropping index equal to 171.49%. Providing rice straw compost, P fertilizer can be saved by 30 kg P₂O₅ ha⁻¹, increasing rice productivity in tidal land. Due to rice straw compost can increase the availability of P, K, Ca, and Mg nutrients in the soil. The use of rice straw compost not only directly increases the availability of good nutrients because it contains nutrients. However, it is also able to improve soil physical properties which are favorable for plant growth.

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