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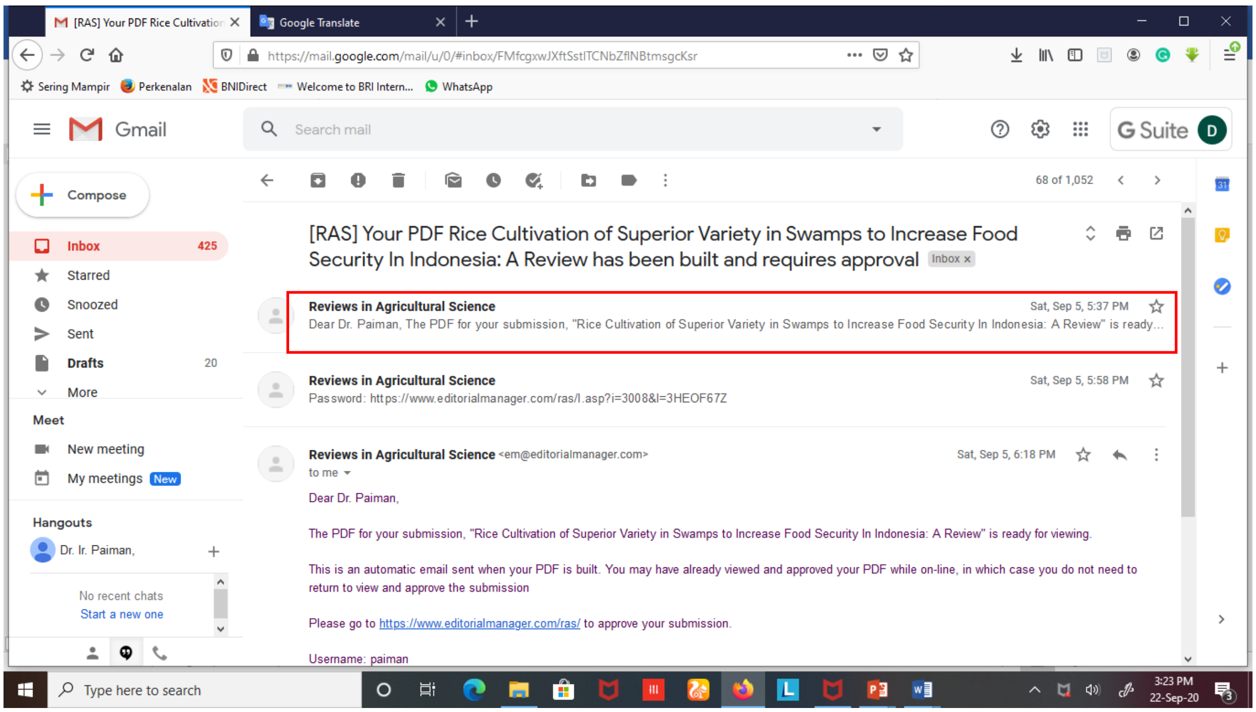

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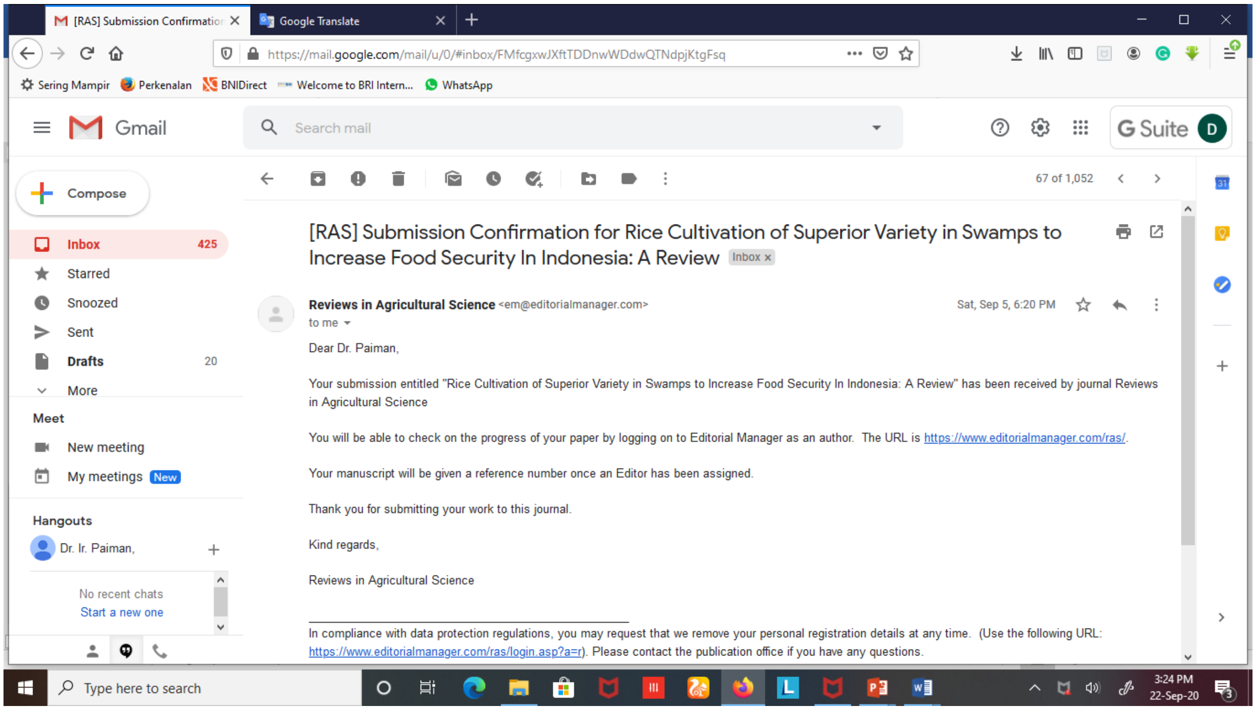

Manuscript to submit

Rice Cultivation of Superior Variety in Swamps to Increase Food Security in Indonesia: A Review

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ABSTRACT

Rice is an important staple food for more than 95% of Indonesians. The need for rice always increases from year to year in line with the increasing population of Indonesia. This review article aims to select superior varieties of rice in swamps to increase food security. The results of the review article indicate that local farmers around the swamps are still low in adopting superior varieties of rice for cultivation. The use of local varieties has been maintained from generation to generation with low rice production. The introduction and use of superior varieties to farmers can be done through outreach from agricultural extension officers. There are two superior varieties for swamps. The Inpara variety is more resistant to standing water

for cultivation in tidal swamps, while the Inpari variety is more suitable in lebak swamps. We hope that the rice cultivation of superior varieties in swamps will have an impact on national food security in Indonesia.
Key words
rice, superior varieties, tidal, lebak, swamps, food security

1. Introduction

Rice is one of the food crops that is cultivated by most of the world′s population. Asian countries dominate global rice production (Gadal et al., 2019), especially in Indonesia. Indonesian population based on the last data recorded in 2015 amounted to 238,518,000 peoples and projected in 2025 it will increase by 284,829,000 peoples (BPS, 2013). Rice consumption is increasing every year, along with the increased Indonesian population (Suryani et al., 2016). Rice is a daily staple food for around 95% of the Indonesian people. Rice has also been a strategic political commodity since the beginning of independence. The Indonesian government has tried hard to increase rice production for national needs (Swastika et al., 2007).

Rice crops as a producer rice into a strategic commodity in terms of aspects economic, social, and political because it involves the lives and basic needs as well as being a priority in supporting agricultural programs (Jumakir et al., 2014). Indonesia is an agrarian country. The farm sector is relied upon to support the country's economy. Since 1984, Indonesia has been a national rice self-help nation in Asia (Maulana et al., 2017). Rice fields are the primary source of rice production. Rice fields area productive narrowed because of the conversion of fertile land in Java become non-agricultural so that the growth of sloping rice production (Swastika et al., 2007). Changing agricultural land (arable land) to non-agriculture will threaten national food security (Elizabeth and Azahari, 2019). The rice harvest area in 2019 is estimated at 10.68 million hectares or decreased by 700.05 thousand hectares (6.15%) compared in 2018. Rice production in 2019 is estimated at 54.60 million tons of dry grain weight or decreased by 4.60 million tons (7.76%) compared in 2018. If rice production in 2019 convertible into rice for population food consumption, so rice production in 2019 of 31.31 million tons or decreased by 2.63 million tons (7.75%) compared in 2018 (BPS, 2020).

Java Island accounts for around 60% of national rice production. Changes in the function of rice fields undermine food availability and food security of the population in Indonesia. There is a problem of decreasing rice production due to function conversion, and while the population continues to grow, it is necessary to look for other alternatives to be developed. The alternative system is the development of agriculture on swamps outside Java, followed by the use of superior rice varieties that are easily adaptable. The superior varieties could be to replace local varieties that have been cultivated from generation to generation by communities around swamps.

2. Superior varieties of rice

Local rice varieties dominate almost 90% of rice cultivation in tidal swampland. This local rice is preferred to be planted. It is an adaptation to submerge tolerantly and rice texture and taste. However, the local rice varieties have a long growing period (8-10 months) and low yield (2.0-2.5 tons/ha) (Koesrini et al., 2018).

Cultivation of local rice cultivars is an integral part of the local culture and traditions of local people together for several generations. The presence of germplasm in the morphological tidal swamp area of South Kalimantan Province has been observed. In Indonesia, as a whole number of 40 local rice cultivars have been found with different morphological characteristics, and until now, it is still being conserved sustainably by farmers around swamps (Mursyidin et al., 2017).

The results of the study have identified local varieties that are resistant or tolerant to bacterial leaf blight, orange leaf blight, brown planthopper, leaf blast, neck explosion, white striped leaf, and dryness. It is also tolerant of Al and Fe toxicity, and abiotic stress (salinity, cold temperature, and shade). The use of local varieties as parent hybridization to obtain superior specific genotypes in new types is highly recommended so that the released varieties have wide genetic diversity (Sitaresmi et al., 2013).

The genetic resources available at Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD) and *International Rice Research Institute* (IRRI) can be used to develop superior varieties. At present, accessions collected in the ICABIOGRAD gene bank are 3,563 cultivated rice plants and 100 wild rice species. Wild rice germplasm is used to develop superior varieties using molecular markers. More than 160 suitable types of rice have been released for the lowlands, highlands, and tidal swamps (Silitonga, 2004). The use of superior varieties that are high yielding, resistant to pests and diseases, and tolerant of abiotic problems can increase rice production (Jamil et al., 2016).

Farmers grow rice in swamplands only once a year during the dry season, where rice cultivation is done after the water in the shallow lebak begins to recede and then followed by middle and deep swampy. The advancement of adaptive rice varieties in the swamp is one of the essential efforts. That needs to be taken so that productivity is higher, resistant to pests and major diseases, and has a good quality of rice. Inpari varieties can grow and provide a good yield in the tidal swamps. Production of Inpari 1, Inpari 4, Inpari 6, and Inpari 13 varieties were planted with a 4:1 of jajar legowo parallelogram system in the middle swampy averaging 6.95 tons/ha grain dry weight (Waluyo and Suparwoto, 2017).

Attempts to assemble rice varieties that are tolerant of global climate change in tidal swamps have been carried out through a cross between a variety of superior and local. There are five cultivars found, namely IR 102860-8: 66-BB, IR 102860-8: 42-BB, IR 101465-8: 23, IR 101465-5: 25, and B13522E-KA-5-B with high yield potential in tidal swamps to deal with climate change. The best comparison is Inpara 9. The parameters used are plant height, the number of productive tillers, and the number of short seeds that have similarities with the character of Inpara 9 (Lestari et al., 2019). Successful rice production will be successful in swamps requiring planting material from superior varieties that are adapted to the environment or swamp ecosystem (Chozin et al., 2019).

Potential hybrid rice was developed to support efforts to increase and stabilization of national rice production, which has been sloping. However, the development and adoption of hybrid rice technology innovation by farmers are not easy, and until now. It is still slow. Hybrid rice is the utilization of the superiority of heterosis in the rice crops, namely F1 derived from a crossing provide performance beyond both parents (Ruskandar, 2010). Crosses between traditional rice cultivars as parents can produce new superior varieties that are more adaptable to swamps. There are two superior adaptive in swamplands, namely

Inpara and Inpari. The Inpari is an acronym from inbrida padi sawah irigasi (Indonesian) or inbred irrigation rice fields (English) and has a varying age between 99-125 days. Still, Inpara is an acronym from inbrida padi Rawa (Indonesian), or inbred rice tidal swamps (English).

The sector of education, extension services, and availability of superior seeds have an essential role in making decisions on the adoption of improved new rice varieties. The use of improved varieties is increased to anticipate hunger and food insecurity in developing countries (Ghimire et al., 2015). The application of biotechnology to improve the quality and quantity of rice production through the transfer of essential traits. Besides that, it can also help reduce the cost of rice cultivation agriculture and increase the nutritional value of rice. Furthermore, biotechnology can also be used to protect the environment, and the natural resource base can be maintained (Lema, 2018). Activity, the introduction of new superior rice varieties are an effort accelerating the development of superior types that have prospects for support food self-sufficiency.

3. Swamps in Indonesia

Indonesia has around 33.43 million ha of swamplands, consisting of 13.3 million ha of lebak swamps and 20.1 million ha of tidal swamps, which are spread across Sumatra, Kalimantan, Papua, and Sulawesi and it could presented in Figure 1 (Maftu'ah et al., 2016). Swamps in Indonesia could be divided into two types, namely tidal and lebak swamp (Sulaiman et al., 2019).

Agricultural development of tidal and lebak swamplands are strategic steps in alternative try efforts to increase food production and offsetting land losses agriculture. Opportunity to develop wetlands as a source of the agricultural output still quite extensive, both seen from the availability of land that has not been or has been cultivated. Generally, its use is not optimal. Technology innovation swamps can be done through water management, fertilizer management, soil amelioration, and improved varieties.

Swamplands are classified as marginal and fragile, so technical aspects must be used as a basis for site selection and technology application. Socio-economic issues play a potential role in the success of agricultural development in swamps. The use of wetlands for agriculture needs to be carried out in three stages. The first is the identification and characteristics of swamps as a basis for determining development priorities based on technical and socio-economic aspects. The second is the selection of land and water management technologies that are appropriate to the soil typology and overflow type. The third is the selection of suitable agricultural commodities (crops, livestock, and fish) from both technical and economic aspects (Suriadikarta and Sutriadi, 2007).

Land characteristics, in general, the lebak swamp has an acidic pH (4-4.5), the texture is characterized by a high content of clay and dust fractions, but the sand fraction is meager, contains a large amount of Ca and Mg, and a small amount of K and Na. The content of organic matter (carbon) in the middle and lower levels of the desert is relatively higher than a dam. Swamp is a suboptimal land with low productivity due to acidity, deficient nutrient, and high levels of toxic (Al, Fe, H_2S) (Kodir et al., 2016). Swampland is marginal land that has a vary of biophysical conditions. The main biophysical problems in agricultural development on tidal swampland include waterlogging, high soil acidity (low soil pH), toxic substances (Al, Fe, H_2S, and Na), low organic matter content, nutrient deficiency (P, Ca, and Mg), and high content of Al, Fe, and Mn.

The content of microelements such as Al, Fe, Mn, B, and S in swamps is high. The high Al and Fe content causes the soil reaction to being very acidic, and the soil pH is low (Helmi, 2015). Iron (Fe) poisoning in rice plants can cause obstacles to growth, seeding, and filling of rice seeds. The distribution of iron concentrations varies in various locations of swamp rice cultivation. Different adverse effects of iron poisoning on rice plants, but the delivery of iron in tidal swamps is still rare. The highest Fe concentration is especially close to the inlet. Rice seedlings must reach a layer of > 10 cm to produce optimal rice production (Mawardi et al., 2020).

Variety of Inpara 3, Inpara 4, and Inpara 5 have unique characteristics when compared to other rice varieties. Inpara 3 variety can survive and produce after experiencing immersion for seven days, while Inpara 4 and Inpara 5 can last for 10-14 days. Inpara 3 is tolerant of water immersion, so it is suitable to be developed in the swampland where water fluctuations in this agroecosystem vary greatly. Inpara 3 can be developed on flood-prone irrigated rice fields. Inpara 1, Inpara 3, and Inpara 7 are equally tolerant of iron (Fe) and aluminum (Al) poisoning, which are essential obstacles in the development of rice plants in the tidal and lebak swampland.

3.1. Tidal swamplands

The tidal swamp is one of the marginal lands that potential a substitution of the fertile field in Java island (Wakhid and Syahbuddin, 2019). The presence of water in tidal swamps is influenced by tides or streams of seawater or rivers, while lebak swamps are affected by rainwater (Sudana, 2005). The characteristics of agricultural land in Java are very different from swamps. Proper farming systems are used to accommodate unique environmental conditions. Tidal swamps are less fertile, non-irrigated, and acidic soils (Yanti et al., 2003).

The area of tidal swamps in Indonesia is estimated to be around 20.1 million ha, spread across Sumatra, Kalimantan, Papua, and Sulawesi. Tidal swamps have been used for 9.53 million hectares of rice cultivation and are a new source of growth in rice production (Suwanda and Noor, 2014). The tidal swamp area in Indonesia was around 34.93 million ha (18.28%) from the terrestrial area of Indonesia, spread in Sumatera of 12.93 million ha, Java of 0.90 million ha, Kalimantan of 10.02 million ha, Sulawesi of 1.05 million ha, Maluku and North Maluku of 0.16 million ha, and Papua of 9.87 million ha. The area of the tidal swamp is around 8.35 million ha in the lands (BPPP, 2019).

Swamplands have the potential to be developed as agricultural land, especially rice. Tidal swamps, freshwater/lebak swamps, and peat, dry land, and non-irrigated land are not functioning optimally. Constraints faced are land productivity, farmer education, and crop indexes are still low. Besides that, there is also a lack of infrastructure, and pest attacks are still high. The application of technological innovation, the quality of human resources, and institutional support are essential opportunities for developing swamps that are not yet optimal (Susilawati and Rumanti, 2018).

Crop calendar map in South Kalimantan tidal swamps successfully prepared based on three climate conditions and expected can be useful as a guide to determine the potential timing of planting in the tidal swampland to increase the rice production. The crop calendar, paddy-planting time in the tidal swampland, potentially could be increased from 1 to 2 times/year on three climatic conditions. Potential of the largest planting area in tidal swampland occurs in terms of dry years, although it is not too different from the wet and normal years (Wakhid and Syahbuddin, 2019).

Local farmers have been maintaining farming systems on tidal swamps for hundreds of years. They have the knowledge and experience to overcome various obstacles and problems associated with cultivating this land. Traditional cultivation systems have been adapted for agricultural practices by maximizing the use of resources on existing land (Yanti et al., 2003). In Central Kalimantan, the contribution of rice supplies from tidal swamps can still be increased. Five strategies can be used, namely increasing productivity, intensification, extensification, and yield safety. The certainty of yield can be used tolerant rice varieties, water management, fertilization, land management, pest and disease control, and improvement of farmer's socio-economic aspects (Irwandi, 2015).

In the tidal swamps area, the canal system is used to manage water availability in the field, which is divided into primary, secondary, tertiary, and quaternary canals. The availability of water in swamps can be controlled so that marshland can be cultivated the rice crops into three growing seasons. The first season will start from November to February to plant rice. The second season is around March to May for rice and other upland food crops, such as corn and soybeans. The third season, which starts from June to August (dry season), is usually used for upland food crops because of the availability of water (Irmawati et al., 2015).

Increased production of rice in the tidal swamp area has potential and good prospects because it is supported by the availability of technology, human resources, and suitable land and agroecosystems. Integrated crop management of technology implementation approaches to support the increased production of rice. Rice production increased from 4,0 to 7,04 tons/ha (Jumakir and Endrizal, 2014).

The development of new superior varieties needs attention to the location specifics and farmers′ preference to the rice characteristic. Based on a variety of productivity new superior that has been tested with the range of results > 6 tons/ha grain dry weight, then it will contribute to an increase in rice production (Adri and Yardha, 2014). As more varieties are released, more farmers have a choice of types that are following their specific desires and territories. It will expand the genetic diversity of plants in the field to reduce the risk of the explosion of certain pests and diseases (Waluyo and Suparwoto, 2017).

Tidal swamps in Indonesia have great potential for inbred and hybrid rice cultivation. Rice planting in this land can only be done once a year. Increased land productivity can be increased through rice cultivation with the ratoon system in this land from rice parent plants after harvest (Susilawati and Purwoko, 2018). The utilization of a tidal swamp to support the above programs has a big opportunity. These opportunities must be supported by various technological innovations, such as water and soil management, including micro water management, landscaping, repair and fertilization, adaptive and productive superior varieties, and agricultural equipment and machinery (Arsyad et al., 2014).

Rice production of 4.04 tons/ha was produced by Inpara 2 and 3 rice varieties 35% higher than Margasari varieties. It shows a useful adaptation in the tidal swamp. Production of 2,118 and 2,275 tons/ha of varieties produced in types of Inpara 1 and 6 was 1.9 and 9.5% higher than varieties of Ciherang. It shows that there is an excellent adaptation in swamps (Koesrini, 2018).

The results of the study were 5 new superior varieties (Inpara 1, Inpara 2, Inpara 3, Inpara 4, and Inpara 5) with 2 varieties as a comparison (Mekongga and Batanghari), showing that Inpara 2 had the highest plant posture compared to other superior varieties and comparators. The highest number of tillers was obtained in Inpara 1 varieties. Inpara 2 and Inpara 4 varieties gave higher yields than 2 comparative varieties. For the development of tidal land in Merauke district, it is recommended to use Inpara 2 and Inpara 4 (Lestari and Kasim, 2014).

South Sumatra has sufficient potential areas for agricultural development in the tidal swamp. Rice varieties (Inpara 1, Inpara 2; Inpara 3, Inpara 6, Inpara 7; and Agrarian 8 and Agrarian 9) are adaptive varieties. In 2017, the largest contributor to rice production was 26.41% from Banyuasin Regency. Rice production is 1,305,533 ton grain dry weight, so a surplus of 733,352 tons (Hendrik, 2018). Area of tidal swamp around 5.9 million hectares owned by Central Kalimantan. About 0.81 million hectares are suitable for rice production, so it has a high contribution to rice availability. No more than 10% of the land has been used for rice cultivation (Irwandi, 2015).

Hybrid varieties can be developed for ratoon cultivation in tidal swamps. At harvest, the staple crop is cut 20 cm from the soil surface and fertilized with 100 kg/ha urea. Ratoon plants have appeared 5-6 days later, with 2-4 leaves and 5.5-26.0 saplings per family. The average age of a ratoon harvest is 69 cutting days. Ratoon yields from hybrids are better than inbred, which is an average of 75.2% of the staple crop. Rice yield is divided into three groups. First, high production (> 2 tons/ha) produced varieties of Hipa 3, Hipa 4, Hipa 5, Maro, Rokan, Ciherang, and Sintanur. Second, middle production (1-2 tons/ha)) produced varieties of Hipa 6, IR42, Margasari, and Mekongga. Third, low production is produced by Batanghari varieties (Susilawati and Purwoko, 2018).

3.2. Lebak swamplands

The Lebak swamp is an area affected by river flooding, not by seawater. Rice cultivation can be done at the end of the rainy season. The classification of the Lebak swamp can be divided into three categories based on their topography and the duration of standing water. First, the shallow embankment is a swamp area above a natural dam with relatively high topography and if there is a very shallow flood or short inundation time. Second, the deep swamp is an area located far from the beach and is a basin that is constantly inundated. Third, the middle swamp is the area that lies between the deep swamp and the shallow embankment (Sulaiman et al., 2019).

Lebak swamp is characterized as always inundated in the rainy season and dry in the dry season. These swamps are grouped into three types, namely: 1) shallow lebak, in the rainy season with a height of < 50 cm for < 3 months, 2) middle lebak, water level between 50 −100 cm for 3-6 months, and 3) deep lebak > 100 cm puddles for > 6 months. Shallow Lebak can be planted with rice and other food crops, while the deep lebak is only for higher local rice (Suriadikarta and Sutriadi, 2007).

The main problem of lebak swamp was high flooding in the wet season and drought in the dry season on the flooding condition. It is not able to be planted cash crops (Waluyo et al., 2008). In general, farmers grow rice in swampy lands only once a year during the dry season, where rice cultivation is done after the water in the shallow swamp begins to recede and then followed by middle and deep swampy. The advancement of adaptive rice varieties in swampland is one of the essential efforts that need to be taken so that productivity is higher, resistant to pests and major diseases, and has a good quality of rice (Suparwoto and Waluyo, 2019).

The low productivity of swamps is due to small soil fertility, the use of old local varieties in the age of 5-6 months, and conventional land management. The main constraints in the development of lebak swamps are inundation and unpredictable drought and depend on the state of the hydro topography, rainfall, and local river water level (Helmi, 2015). The trend of rainfall more lucrative than the pattern of evapotranspiration. Besides that, the evapotranspiration value was higher than the rain. It often causes dry conditions during drought. The amount of evapotranspiration is not affected by rainfall, but by the area of land cover. The water level is strongly influenced by rainfall, tides river, and runoff (Puspitahati et al., 2017).

The total area of lebak swamp in Indonesia is 13.27 million ha, and only 4 million ha have been developed. The 2.6 million ha of swamps are managed by the public and the private sector, while the 1.3 million ha is through government assistance (Muhakka et al., 2019). Lebak swamp that has been planted for agricultural (especially rice) is new around 694,291 ha (5%) out of a total area of 13.2 million ha. The width of lebak swamp area rice has been planted by once in the largest Province of South Sumatera (148,979 ha), Central Kalimantan (114,500 ha), and West Kalimantan (102,200 ha). The other Province area of rice planted with one-time rice, on average less than 100,000 ha. Lebak swamp, which has been cultivated twice a year, namely Province of Riau, South Kalimantan, West Kalimantan, and Central Kalimantan with each area more than 10,000 ha, but the other Province on average less than 10.000 ha. Progress in land use for agricultural business is still low, so it has an excellent opportunity to act as a source of agricultural growth (Sudana, 2005). The area of lebak swamp is 11.64 million ha, mostly on the low terrestrial, except in Sumatera, around 0.03 million ha (BPPP, 2019).

Development of tidal swamps for agriculture requires land and water management and application of technology under land conditions to obtain optimal yields in addition to socio-economic conditions, institutions, and supporting infrastructure. Accelerating agricultural development in tidal swamp should be done through four subsystems, namely land development, cultivation development, mechanization and post-harvest, and institutions. Agricultural innovations can be used as the foundation for the development of the acceleration of farming in the swamps (Effendi et al., 2014).

Lebak swamps in Jakabaring (South Sumatera Province) can be divided into six typologies, namely lebak lebung, deep lebak, middle lebak, levee lebak, shallow lebak, and dry land. After landfilling, dry land area has increased becoming 1,964 ha (72.73%). In comparison, another lebak swamp is only about 736 ha (27.27%) consisting of shallow lebak 380.97 ha (14.11%), deep lebak (127.71 ha (4.73%), levee lebak 87.21 ha (3.23%), middle lebak 82.89 ha (3.07%) and lebak lebung only 57.51 ha (2.13%). Total rice production was around 3,240 tons dry weight of grain per year before landfilling. In the existing condition, its potency remains only 506.25 tons. The availability of water in swamps can be controlled so that wetlands can be cultivated in the rice into three growing seasons. The first season will start from November to February to plant rice per year (Wildayana and Armanto, 2018).

In 2012, the width of the lebak marsh in Lampung Province reached 55,714 ha with a rice productivity level of 5.13 tons/ha and still has the opportunity to be increased. Production can be increased through increasing land productivity and cropping indexes, reducing yield gaps, and reducing yield losses. This increase in production will have an impact on improving food availability, both regionally and nationally (Pujiharti, 2017).

The use of new superior varieties in swampy land can increase rice production. Inpara and Inpari varieties can grow and produce in the shallow and middle swamps. In shallow swamps, it is better to use drought-tolerant varieties such as Situbagendit, Limboto, Batutegi, Inpago, Inpari-1, Inpari-4, Inpari-6, Inpari-6, and Inpara-5. Rice cultivation in the deep lebak swamp can only be cultivated once a year. The use of superior varieties that are resistant to immersion is recommended, namely Inpara-3, Inpara-4, and Inpara-5 (Suparwoto and Waluyo, 2019).

Higher rice productivity is produced by varieties Inpara 1, Inpara 2, and Inpara 3 compared to rice varieties for other swamps. Likewise, Mekongga varieties can still provide good productivity in lowland swamps (Helmi, 2015). Rice production of 4.9, 6.8, 6.1, and 7.0 tons/ha of dry unhusked rice are produced by Inpari 15, Inpari 22, Inpari 30, and Inpara 4. Financially, the use of superior varieties Inpari 22, Inpari 30, and Inpara 4 deserve to be developed because it is profitable (Guwat et al., 2015). The optimum fertilizer dosage on lebak swamps per hectare for Inpara 3 variety rice is 300 kg urea, 50 kg SP-36, and 150 kg KCl. Observations obtained as many as 16.1 tillers, 15.7 panicles, and 45.9 g dry weight of grain per clump (Rois et al., 2017). Rice production of Inpari 9 and Inpara 4 varieties is higher than Mekongga, and IR 42, which is 7.7 and 7.6 tons/ha dry weight of grain in lebak swamp (Suparwoto, 2019).

4. Conclusions

Rice is one of the food crops that is cultivated by most of the world′s population, especially Indonesia. Rice is an outstanding staple food for more than 95% of Indonesian peoples. Rice fields are narrowed because of the conversion of fertile land to become non-agricultural. Rice consumption is increasing every year, along with the increased Indonesian population. The land for agriculture on Java island has decreased from year to year. Rice cultivation had to be diverted to marginal land outside Java in the form of swamps. Agricultural development of swamplands is strategic steps in alternative try efforts to increase food production and offsetting land losses agriculture. Swamp in Indonesia is still relatively broad and not yet optimal its utilization.

The local farmers around the swamps are still low in adopting superior varieties of rice for cultivation. The use of local varieties has been maintained from generation to generation with low rice production. The introduction and use of superior varieties to farmers can be done through outreach from agricultural extension officers. There are two superior varieties for swamps. The Inpara variety is more resistant to standing water for cultivation in tidal swamps, while the Inpari variety is more suitable in lebak swamps. We recommended that the rice cultivation of superior varieties in swamps will have an impact on national food security in Indonesia.

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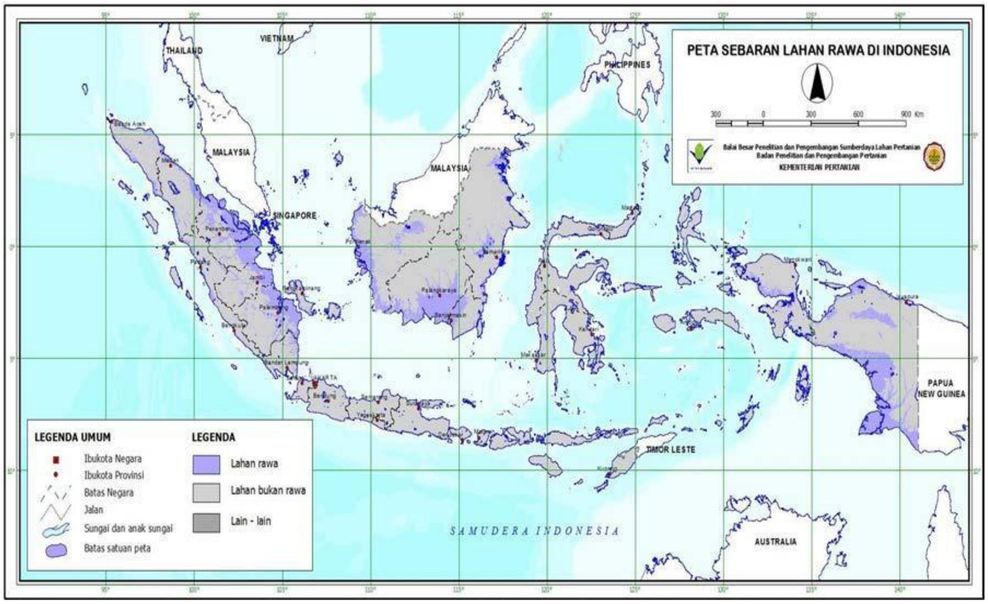
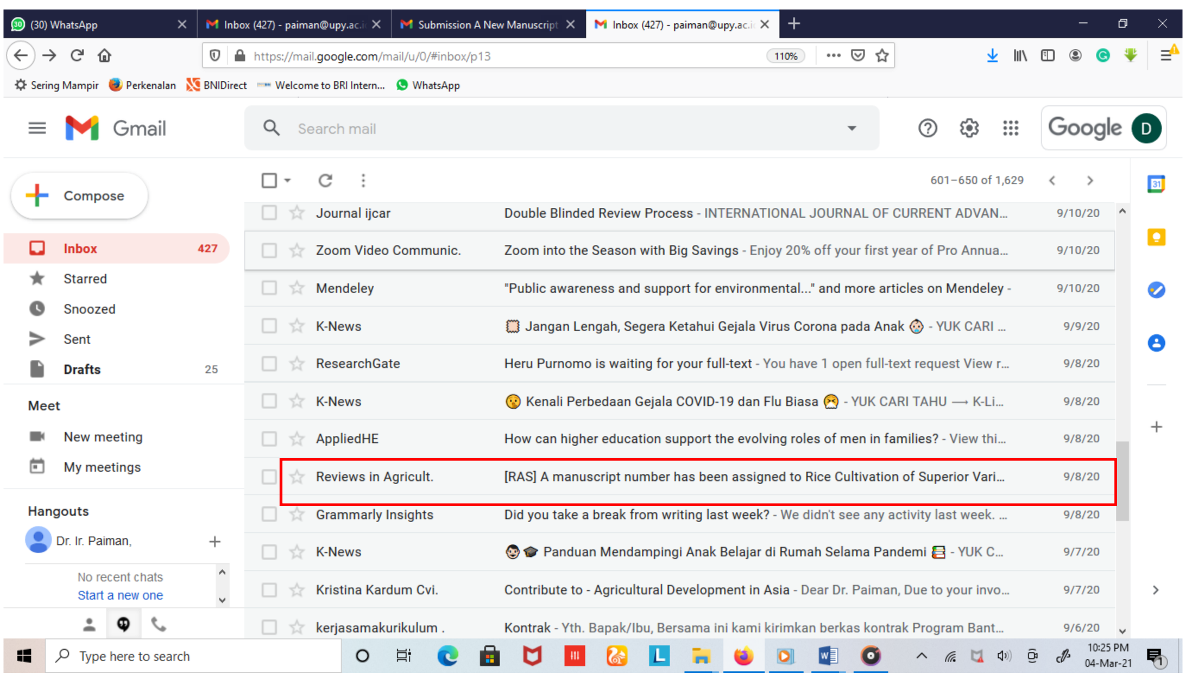


Source: BBSDLP (2014) cit. Maftuah et al. (2016)

Figure 1. Map of swamps distribution in Indonesia

2. Manuscript Assigned: 8 September 2020



Gmail — Dr. Ir. Paiman, M.P. - UPY <paiman@upy.ac.id>

[RAS] A manuscript number has been assigned to Rice Cultivation of Superior Variety in Swamps to Increase Food Security In Indonesia: A Review

Reviews in Agricultural Science <em@editorialmanager.com> — Tue, Sep 8, 2020 at 8:38 AM
Reply-To: Reviews in Agricultural Science <ras2019@gifu-u.ac.jp>
To: Paiman Paiman <paiman@upy.ac.id>

Dear Dr. Paiman,

Your submission entitled "Rice Cultivation of Superior Variety in Swamps to Increase Food Security In Indonesia: A Review" has been assigned the following manuscript number: RAS-D-20-00019.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author.
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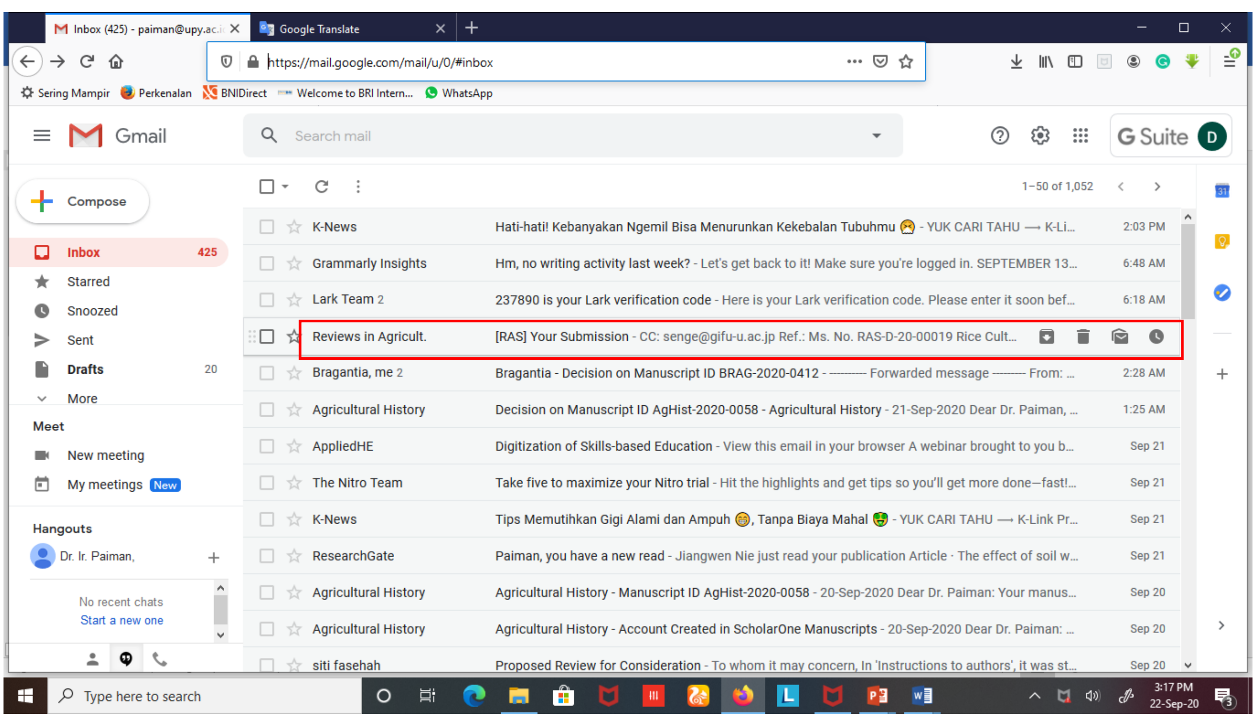

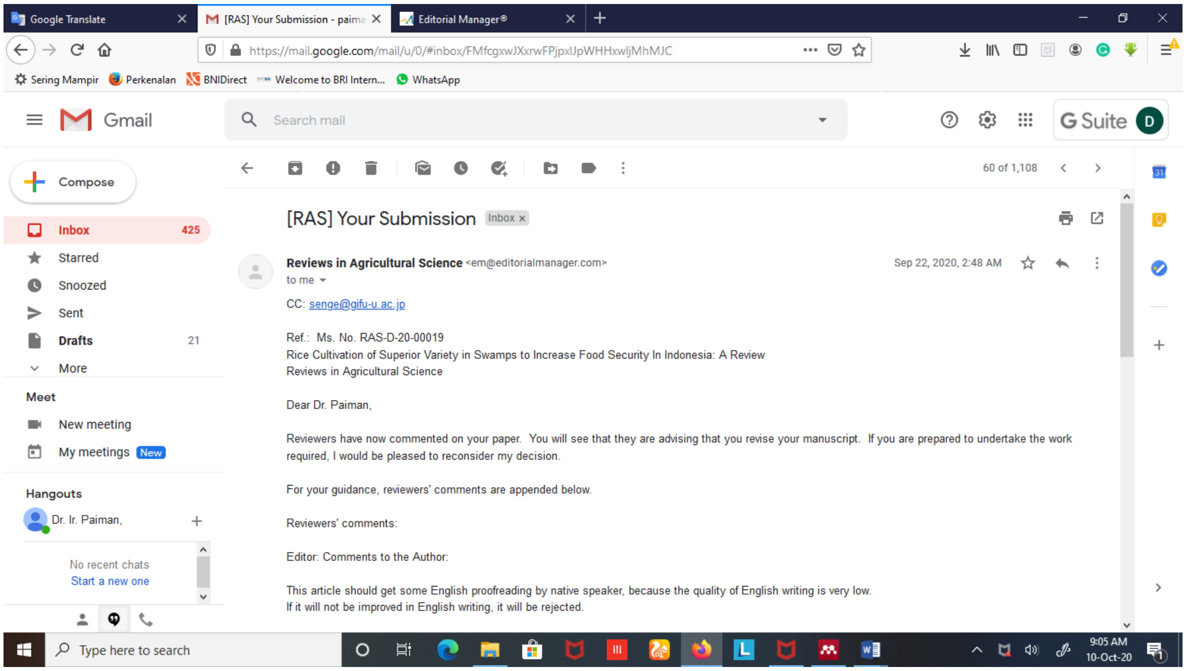

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Dear Dr. Paiman,

Reviewers have now commented on your paper. You will see that they are advising that you revise your manuscript. If you are prepared to undertake the work required, I would be pleased to reconsider my decision.

For your guidance, reviewers' comments are appended below.

Reviewers' comments:

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This article should get some English proofreading by native speaker, because the quality of English writing is very low.
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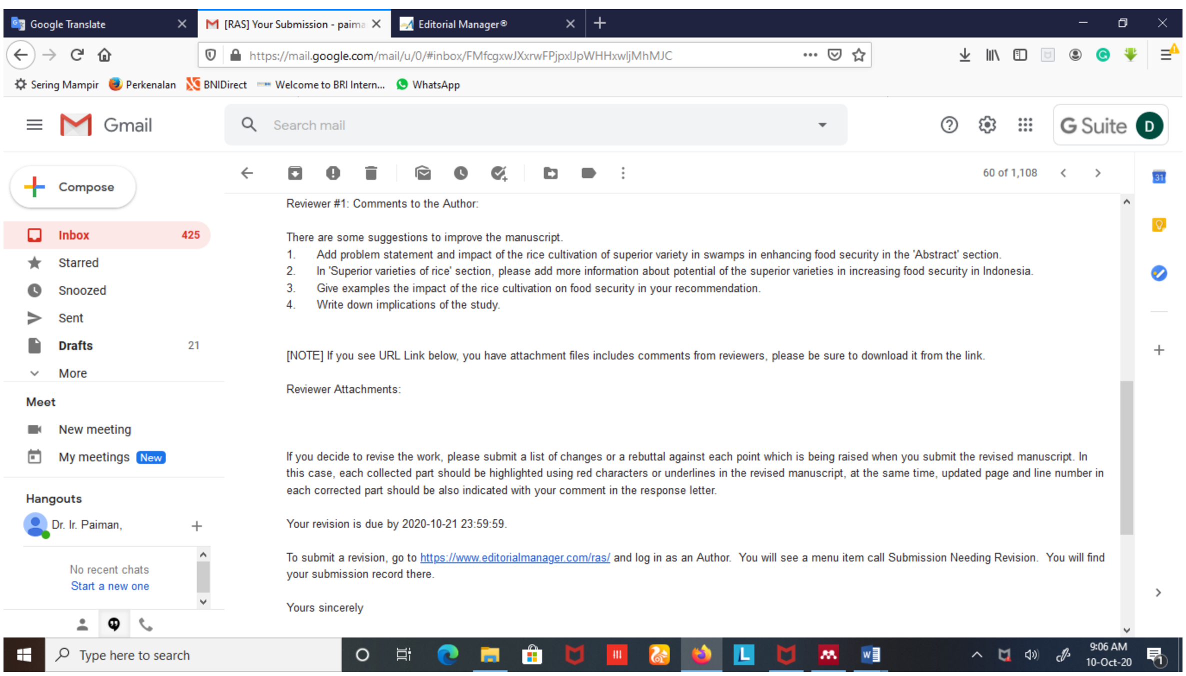

Reviewer #1: Comments to the Author:

There are some suggestions to improve the manuscript.

1. Add problem statement and impact of the rice cultivation of superior variety in swamps in enhancing food security in the 'Abstract' section.
2. In 'Superior varieties of rice' section, please add more information about potential of the superior varieties in increasing food security in Indonesia.
3. Give examples the impact of the rice cultivation on food security in your recommendation.
4. Write down implications of the study.

[NOTE] If you see URL Link below, you have attachment files includes comments from reviewers, please be sure to download it from the link.

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If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript. In this case, each collected part should be highlighted using red characters or underlines in the revised manuscript, at the same time, updated page and line number in each corrected part should be also indicated with your comment in the response letter.

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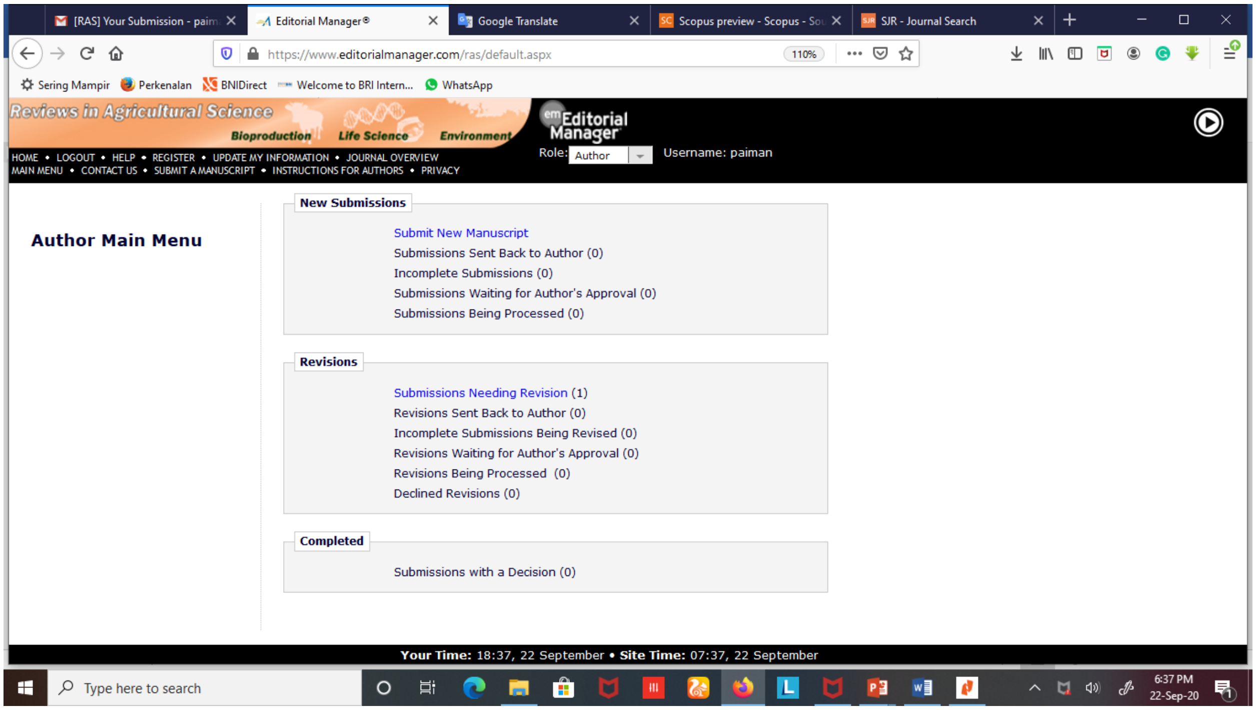
Yours sincerely



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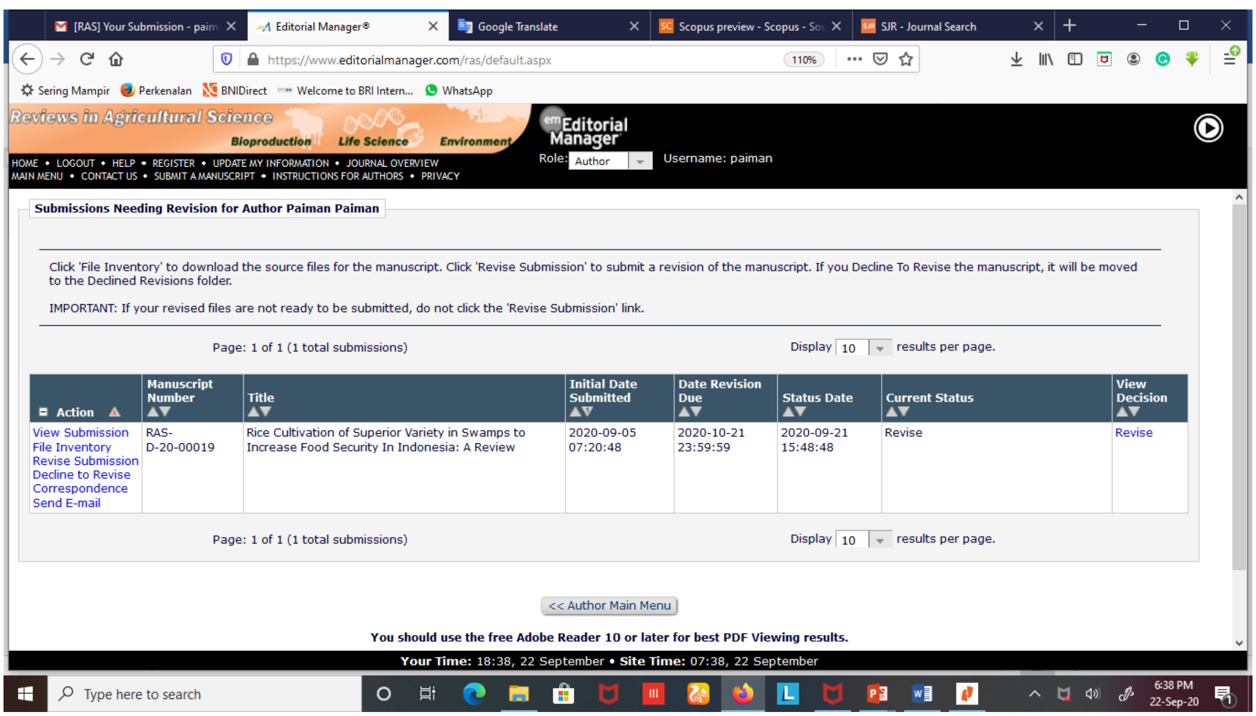

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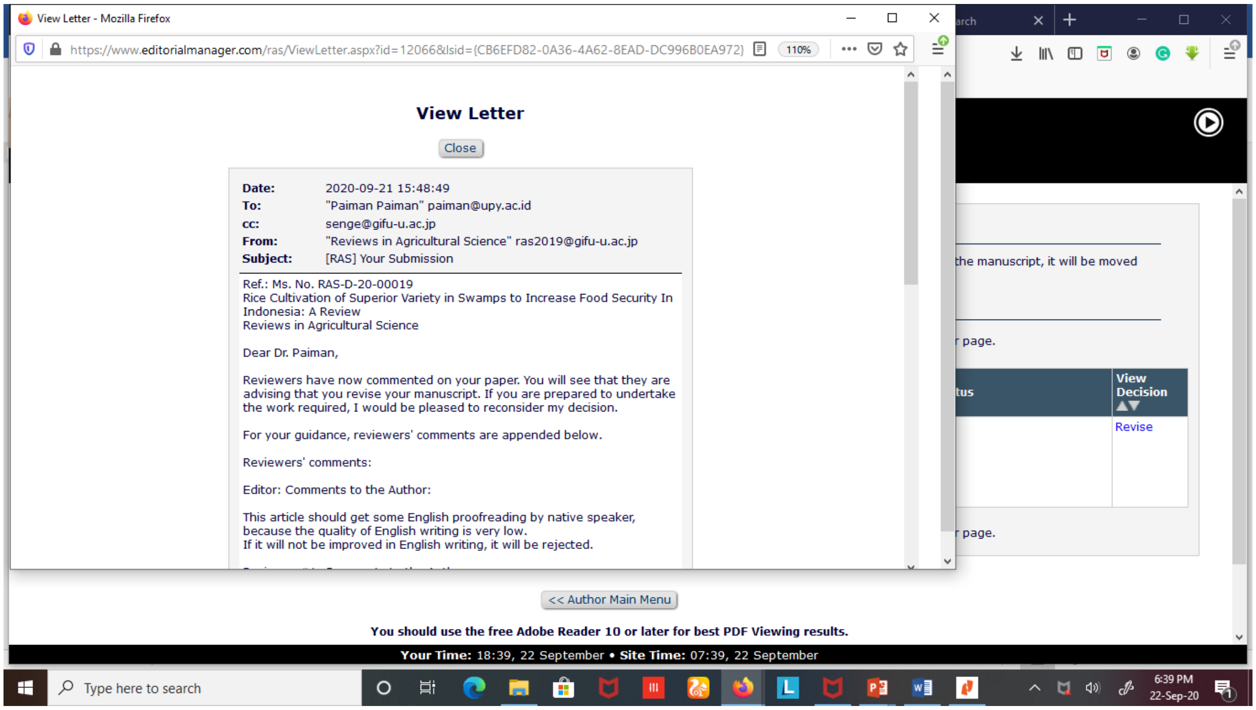

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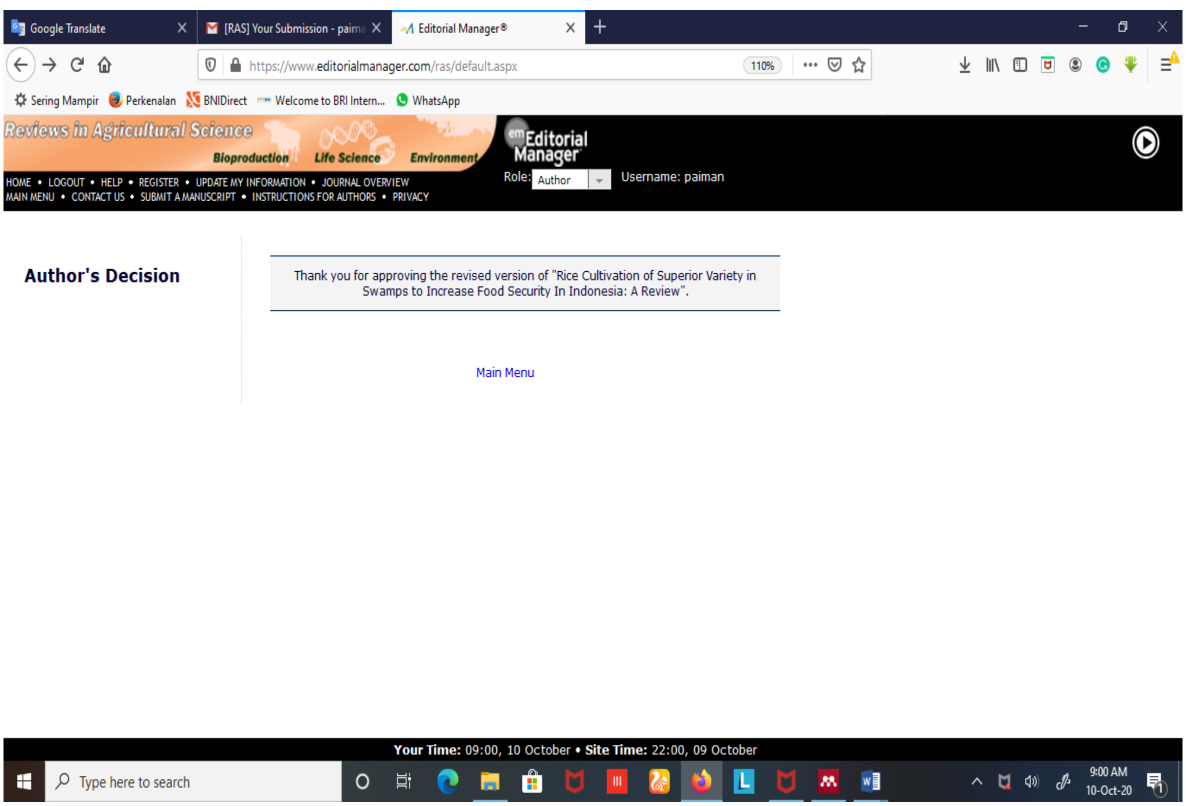

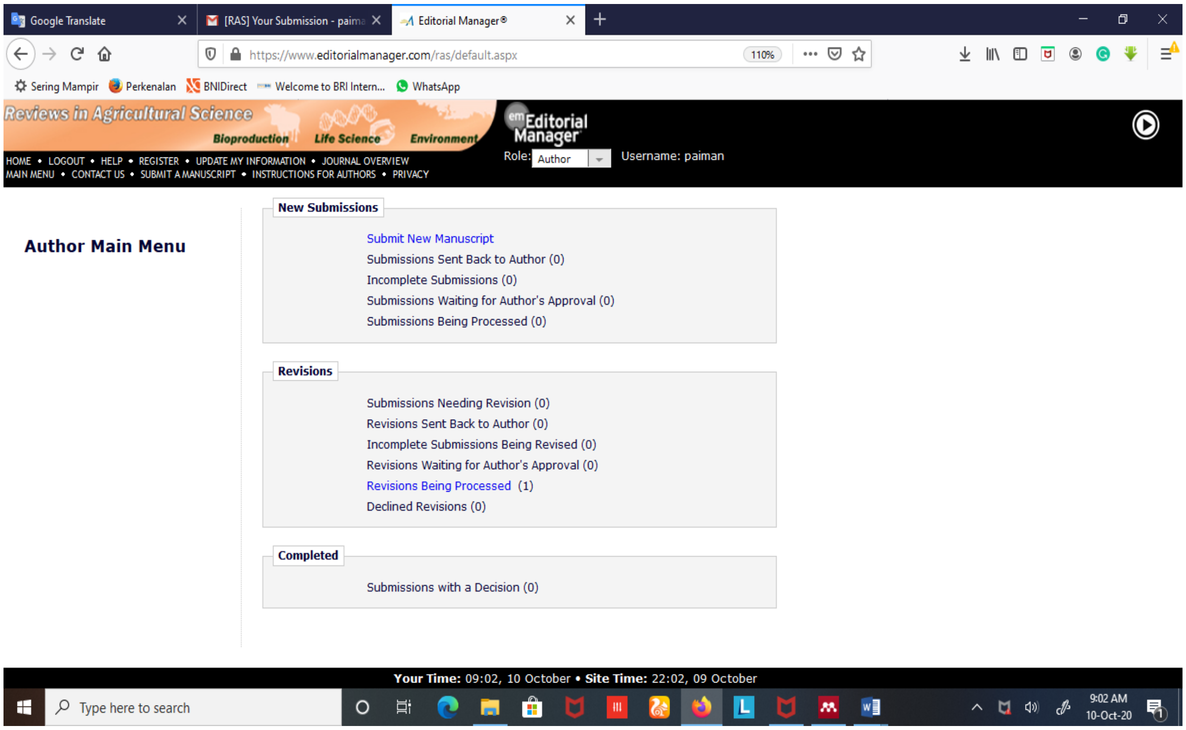

Respond To Reviewers

We have made improvements to the quality manuscript of English writing. Comments and improvements to the article we have added to the manuscript with a red sentence mark.

Editor comments: This article should get some English proofreading by native speaker, because the quality of English writing is very low.

- ➢ Manuscript has been improved through the help of English proofreading team so that the quality is better.

Reviewers comments:

1. Add problem statement and impact of the rice cultivation of superior variety in swamps in enhancing food security in the 'Abstract' section.
   - ➢ Problem statement we have added in the abstract section on lines 26-31 of manuscript. The impact of the rice cultivation of superior variety in swamps in enhancing food security has been added on lines 39-41 of manuscript.

2. In 'Superior varieties of rice' section, please add more information about potential of the superior varieties in increasing food security in Indonesia.
   - ➢ Information about potential of the superior varieties in increasing food security in Indonesia has been added in the “Superior varieties of rice” section on lines 126-136 of manuscript.

3. Give examples the impact of the rice cultivation on food security in your recommendation.

- We have added an example of the influence of rice cultivation on food security in the recommendations on lines 336-339 of manuscript.

4. Write down implications of the study.
   - We have written the implications of the study on lines 41-42 of manuscript.

Submit: Manuscript Revision

Rice Cultivation of Superior Variety in Swamps to Increase Food Security in Indonesia: A Review

Paiman[1,*], Ardiyanta[1], Muhammad Ansar[2], Iqbal Effendy[3] and Bernadus T. Sumbodo[4]

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Total number of words: 5791

ABSTRACT
The island of Java is Indonesia's largest rice production. However, the conversion of land into industrial areas and construction projects has contributed to the decline of rice production on the island. Therefore, it is necessary for the country to expand its agricultural site outside of Java island through the utilization of swampland. Indonesia has large areas of swampland, which have not made the most of it. The swampland farmers have never grown high quality of rice. Thus, the selection of high-quality rice is considered to increase rice production in the swampland. This article aims to discuss the rice cultivation of superior variety in the swamp to improve national food security. The result of this research showed that local farmers in the swamp area rarely adopt high-quality rice. In fact, local rice variety has low productivity and longer lifespan. Therefore, the use of the superior quality of rice is expected to boost rice production. Nevertheless, the Government of Indonesia has developed numbers of high-quality rice such as *Inpara* and *Inpari*, which are more adaptive in the swampland. The *Inpara* is more resistant to standing water for tidal swamps, while the *Inpari* is more suitable in *lebak* swamps (most of the year inundation). The use of *Inpara* and *Inpari* in swampland can increase rice production. The implications of rice cultivation of superior varieties are increased productivity and crop index due to shorter rice life, resistance to pest and disease attacks, and tolerance of marginal environmental conditions. The use of superior variety can increase rice production and crop index, thus supporting food security in Indonesia.
Keywords

rice, superior variety, swampland, food security

5. Introduction

Rice is one of the food crops cultivated by most of the world's population. Asian countries dominate global rice production (Gadal et al., 2019), especially in Indonesia. The people of Indonesia in 2015 was 235,180,000 and is estimated in 2025 to be 284,829,000 (BPS, 2013). Rice consumption increases every year, as the population increases (Suryani et al., 2016). Rice is a daily staple for about 95% of Indonesia's population. Rice has also been a strategic political commodity since the beginning of independence. The Government of Indonesia has gone to great lengths to increase rice production for national needs (Swastika et al., 2007).

Rice crops become a strategic commodity in economic, social, and political aspects because they support agricultural programs (Jumakir et al., 2014). Indonesia is known as an agricultural country. The farm sector is relied upon to support the country's economy. Since 1984, Indonesia has been a national rice self-sufficiency country (Maulana et al., 2017). Rice fields are the primary source of rice production. The island of Java is the center of rice production in Indonesia. However, the area of fertile rice fields in Java is narrowing because of converting productive land functions to non-agricultural sectors, which rapidly diminished rice production (Swastika et al., 2007). The conversion of farmland to non-agricultural use will threaten national food security (Elizabeth and Azahari, 2019). In 2019, Indonesia's rice harvest area was 10.68 million ha, and the recorded decrease was of 700.05 thousand ha (6.15%) compared to 2018. In 2019, rice production was 54.60 million tons of dry grain and decreased by 4.60 million tons (7.76%) compared to 2018. Rice production in 2019 was 31.31 million tons or decreased by 2.63 million tons (7.75%) compared to 2018 (BPS, 2020).

The island of Java contributed to 60% of national rice production. The conversion of agricultural land undermines the availability of food and Indonesian food security. The growing population requires a proper solution for decreasing agricultural land. Therefore, the utilizing of swampland outside Java island for growing superior rice is considered the best solution. The application of technology through the cultivation of a superior variety of rice is expected to replace the less productive of the local type. Considering the crucial role of rice production to Indonesian food security, The Government of Indonesia has provided an alternative to the issue through the innovation of rice varieties, which are more adaptive to the Indonesian swampland.

6. A superior variety of rice

Local rice variety dominates nearly 90% of rice cultivation in tidal swampland. This local rice is more widely grown because it is stagnant tolerant. On the other hand, however, the harvest period takes longer (8-10 months) and low yield (2.0-2.5 tons/ha) (Koesrini et al., 2018). Local rice cultivation has been an integral part of the local culture and traditions of the local community for generations. Indonesia has 40 local rice cultivars with different morphological characteristics. Currently, those local rice variety is still preserved by farmers around swampland (Mursyidin et al., 2017).

Local variety has resistance to bacterial leaf disease, citrus leaf disease, brown planthoppers, leaf explosions, neck explosions, white striped leaves, and drought. Still, they are prone to Al, Fe, and abiotic stress (salinity, cold temperature, and shade). The use of local variety is recommended as a master hybridization to obtain specific genotypes that excel at new types. Thus, the released varieties have a broad genetic diversity (Sitaresmi et al., 2013).

The genetic resources are available at the Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD), and *International Rice Research Institute* (IRRI) can use to develop superior varieties. At present, accessions collected in the ICABIOGRAD gene bank are 3,563 cultivated rice plants and 100 wild rice species. The Indonesian government has released more than 160 types of rice for lowlands, highlands, and tidal swamps (Silitonga, 2004). The use of superior variety potentially has higher production, is resistant to pests and diseases, and is tolerant to abiotic problems (Jamil et al., 2016).

The rice cultivation on swampland is carried out gradually. Rice plants can only be planted once a year during the dry season in swampland after the water in the shallow *lebak* begins to recede. Then the middle and deep swamps follow the planting. Thus, the use of an adaptive variety of rice in swampland is one of the essential efforts. It is necessary to increase rice production, resistant to pests and major diseases, and has good rice quality (Waluyo and Suparwoto, 2017). The rice variety is tolerant of global climate change in tidal swamps through superior and local crossbreeding. There are five cultivars found, namely *IR 102860-8: 66-BB, IR 102860-8:42-BB, IR 101465-8:23, IR 101465-5:25,* and *B13522E-KA-5-B* with high yield potential to deal with climate change. The best comparison is *Inpara 9*. This variety has high parameters of the number of productive puppies and short seeds that have similarities with the character of *Inpara 9* (Lestari et al., 2019). Successful rice production in swampland requires planting materials from superior variety adapted to the environment or ecosystem (Chozin et al., 2019).

However, the development and adoption of technological innovation by farmers are not accessible. Superior variety utilizes the advantages of heterocyst from rice crops, namely F1, which provides performance beyond both parents (Ruskandar, 2010). Crossbreeding between traditional rice cultivars as parent stock can produce a new superior variety that is more adaptable to swamps. There are two superior adaptive in swamplands, namely *Inpara* and *Inpari*. The *Inpari* is an acronym from *inbrida padi sawah irigasi* (Indonesian) or inbred irrigation rice fields (English) and has a varying age between 99-125 days. Still, *Inpara* is an acronym from *inbrida padi rawa* (Indonesian), or inbred rice tidal swamps (English).

The education, counseling, and availability of superior seeds play an important role in adopting a superior variety of rice. In line with the statement, Ghimire et al. (2015) asserted that the use of selected varieties could anticipate hunger and food insecurity in developing countries. According to Lema (2018), the application of biotechnology improves the quality and quantity of rice production through the transfer of essential properties. Besides, it can also help reduce the cost of rice cultivation and increase nutritional value. Biotechnology can protect the environment and natural resources.

The rice character of superior variety has higher yield potential, can adapt to the environment of swampland, and is resistant to pest attacks and diseases (Sasmita et al., 2019). Superior variety has resistance to biotype two brown planthopper pests, path type III, and brass leaf disease, and are tolerant of Fe and Al poisoning (Danial & Sulhan, 2017). Superior variety is a significant component of technology that can contribute to increased rice production.

The Ministry of Agriculture has released 11 rice varieties for swampland since 2008-2019, namely: *Inpara 1, Inpara 2, Inpara 3, Inpara 4, Inpara 5, Inpara 6, Inpara 7, Inpara 8 Agritan, Inpara 9 Agritan, Inpara 10 BLB,* and *Purwa* (Sasmita et al., 2019). Based on recent literature, there are some varieties of *Inpari* and others that are adaptive to cultivate on swampland. The use of superior variety is an effort to accelerate the development of rice that has great pretension to support food self-sufficiency.

7. Swamps in Indonesia

Indonesia has about 33.43 million ha of swampland, consisting of 13.3 million ha of swamp and 20.1 million ha of a tidal wetland. Swampland spreads across in Sumatra, Kalimantan, Papua, and Sulawesi (Fig. 1) (Maftu'ah et al., 2016). There are two types of swampland in Indonesia: tidal and *lebak* swamp (Sulaiman et al., 2019). The development of tidal and *lebak* swamp is a strategic step and an alternative solution to increase food production and offset agricultural land losses. The opportunity to develop swamp as a source of agricultural produce is still quite broad, either from the availability of land that has not been or has been managed. In general, swampland in Indonesia has not been optimally used and developed.

Swampland is marginal and fragile land. Hence, the technical aspects are the principle for selecting technology applications. Socio-economic issues play a potential role in the success of agricultural development on swampland. Use of swamp for agriculture through three stages. The first is the identification and characteristics of the marsh as the basis for determining development priorities based on technical and socio-economic aspects. The second is to select land, water management technology that corresponds to soil typology, and overflow. The third is the selection of suitable agricultural commodities (crops, livestock, and fish) both from technical and economic aspects (Suriadikarta and Sutriadi, 2007).

In general, the nature of swampland has an acidic pH (4-4.5), the texture is a high fraction of clay and dust, a slight fraction of sand, and low Ca, Mg, K and Na. Swampland is less than optimal land with low productivity due to acidity, malnutrition, and high toxic (Al, Fe, H2S) (Kodir et al., 2016). The content of microelements such as Al, Fe, Mn, B, and S is relatively high in swampland. High Al and Fe content causes soil reactions to become highly acidic, and soil pH is low (Helmi, 2015). Iron poisoning (Fe) in rice crops can cause barriers to growth, seeding, and grain filling. The distribution of iron concentrations varies in various swampland locations, so the side effects of iron poisoning on rice crops also vary. The highest Fe concentration occurs in areas close to the in waterways. Rice seedling planting must reach a depth layer of more than 10 cm to produce optimal rice production (Mawardi et al., 2020). The characteristics of bronzing indicate iron toxicity in plants. Higher iron uptake by plants decreased protein synthesis in the leaves (Rout and Sahoo, 2015).

Inpara 3, Inpara 4, and *Inpara 5* have unique characteristics compared to other rice varieties. *Inpara 3* can survive after seven days of immersion, while *Inpara 4* and *Inpara 5* can last 10-14 days. *Inpara 3* is tolerant of water immersion, so it is suitable for swampland with water fluctuations in this agroecosystem varies greatly. *Inpara 3* is an appropriate variety for flood-prone irrigation land. *Inpara 1, Inpara 3,* and *Inpara 7* are tolerant of iron poisoning (Fe) and aluminum (Al), which are essential obstacles in developing rice crops in tidal and *lebak* swamp.

7.1. Tidal swamplands

The tidal swamp is one of the marginal lands that can replace fertile land in Java (Wakhid and Syahbuddin, 2019). Tidal water in swampland is affected by tides or seawater flows or rivers, while *lebak* swamp is affected by rainwater (Sudana, 2005). The characteristics of agricultural land in Java are very different from the swamp. The right agrarian system can accommodate unique environmental conditions. Tidal swampland has less fertile, irrigated, and acidic soil (Yanti et al., 2003).

The area of tidal swampland in Indonesia is estimated at around 20.1 million ha, spread across Sumatra, Kalimantan, Papua, and Sulawesi. The tidal swamp that has been used for 9.53 million ha for rice cultivation and is a new source of rice production (Suwanda and Noor, 2014). The area of tidal swampland in Indonesia is approximately 34.93 million ha (18.28%) terrestrial regions of Indonesia. The map covers 12.93 million ha of Sumatra, Java 0.90 million ha, Kalimantan 10.02 million ha, Sulawesi 1.05 million ha, Maluku and North Maluku 0.16 million ha, and Papua 9.87 million ha (BPPP, 2019). The Ministry of Agriculture seeks to increase food production, especially rice nationally. The total tidal land area in Indonesia is 20.11 million ha. The land can be a source of rice production, but only 9.53 million ha is utilized. If 50% of the land could be used for rice cultivation, it would produce about 14.295 million tons of dry grain per year (Mamat and Noor, 2018).

Swampland potentially can be developed as agricultural land, especially for the cultivation of rice crops. However, the utilization of tidal swamps and freshwater or *lebak* swamp has not been optimal. The obstacles are low land productivity, low farmer education, lack of infrastructure, and pest attacks are still high. The application of technological innovation, quality of human resources, and institutional support is a significant opportunity to develop swampland (Susilawati and Rumanti, 2018). Rice planting time in tidal land can be increased from once to twice/year in three climatic conditions. The utilization of potential tidal swampland occurs in reduced water conditions, although not too different from wet and standard shapes (Wakhid and Syahbuddin, 2019).

Local farmers have maintained agricultural systems on tidal swampland for hundreds of years. They have the knowledge and experience to overcome the various obstacles and problems associated with the cultivation of this land. Traditional rice cultivation systems for agricultural practices have maximized existing natural resources (Yanti et al., 2003). Increasing the contribution of rice supply from Central Kalimantan through productivity improvement, intensification, extensive, and yield safety. The safety of crops can be improved through tolerant rice varieties, water management, fertilization, land management, pest and disease control, and improved socio-economic aspects of farmers (Irwandi, 2015).

In tidal swamp areas, waterway systems are useful for regulating the availability of water on land into primary, secondary, tertiary, and quaternary canals. Proper management of water availability in swampland allows in one year to three times harvest. The first harvest season starts in November-February, only able to grow rice. The second harvest season is in March-May for rice crops and other highland food crops, such as corn and soybeans. The third harvest season in June-August (dry season) can cultivate highland food crops due to limited water availability (Irmawati et al., 2015).

Increasing rice production in tidal swamp areas has potential and promising prospects due to the support of the right technology, human resources, land, and agroecosystems. Integrated plant management is a technology implementation approach to support increased rice production. Rice production increased from 4.0 to 7.04 tons/ha (Jumakir and Endrizal, 2014).

The development of new superior variety needs consideration regarding location specifics and farmers' preference for rice crop characteristics. The productivity of excellent types has a yield range of more than 6 tons/ha of the dry grain harvest, contributing to increased rice production (Adri and Yardha, 2014). The government has mostly removed superior variety for swampland so that farmers can choose the type that suits their territory. It will expand the genetic diversity of plants in the field to reduce the risk of explosions of certain pests and diseases (Waluyo and Suparwoto, 2017).

Tidal swamps in Indonesia have great potential for inbred and hybrid rice cultivation. However, for one year can only grow rice once. Increased land productivity can be through rice cultivation with a ratoon system after harvest (Susilawati and Purwoko, 2018). Tidal swampland utilization has considerable opportunities to support the above programs. Support a wide range of technological innovations, such as water and soil management, landscaping, fertilization, adaptive and productive superior variety, and agricultural equipment and machinery to take advantage of opportunities (Arsyad et al., 2014).

Inpara 2 and *Inpara 3* produce dry grain of 4.04 tons/ha or 35% higher than the *Margasari* variety. It indicates a useful adaptation in tidal swampland. *Inpara 1* and *Inpara 6* are 2,118 and 2,275 tons/ha of dry grain or 1.9 and 9.5% higher than the *Ciherang* variety. It shows an excellent adaptation of *Inpara* in swampland (Koesrini, 2018). The results showed five types, namely *Inpara 1, Inpara 2, Inpara 3, Inpara 4, and Inpara 5*, with *Mekongga* and *Batanghari* variety comparisons. Rice growth shows that *Inpara 2* has the highest crop posture compared to other superior varieties and comparators. The highest number of puppies is obtained by *Inpara 1*. *Inpara 2* and *Inpara 4* provide higher results than the two comparative types. Rice development in tidal land in Merauke Regency is more suitable using *Inpara 2* and *Inpara 4* (Lestari and Kasim, 2014).

South Sumatra has good enough potential for rice farming development in tidal swampland. Rice of *Inpara 1, Inpara 2, Inpara 3, Inpara 6, Inpara 7, Agrarian 8,* and *Agrarian 9* are adaptive varieties. Banyuasin regency is a contributor to rice production of 26.41% or 1,305,533 tons of dried grain harvested in 2017, resulting in a surplus of 733,352 tons (Hendrik, 2018). Central Kalimantan has an area of tidal swamps of about 5.9 million ha. About 0.81 million ha is suitable for rice production, thus contributing highly to the availability of rice. No more than 10% of swampland has been used for rice cultivation (Irwandi, 2015).

The development of ratoon rice cultivation in tidal swampland can use hybrid variety. During harvest, the stem of the staple plant is cut 20 cm from the ground level and fertilize with urea 100 kg /ha. Ratoon plants have appeared 5-6 days with 2-4 leaves and 5.5-26.0 puppies per clump. The average age of ratoon harvesting is 69 days from cutting stems. Ratoon produced an average of 75.2% of the yield of staple crops. Grouping rice crops into three parts from a high, medium, and low production. The first groups were *Hipa 3, Hipa 4, Hipa 5, Maro, Rokan, Ciherang*, and *Sintanur* variety produced more than 2 tons/ha. The second groups were *Hipa 6, IR42, Margasari*, and *Mekongga* variety made 1-2 tons/ha. The third was the Batanghari variety produced less than 1 tons/ha (Susilawati and Purwoko, 2018).

7.2. *Lebak* swamp

Lebak swamp is an area affected by river flooding, not by seawater so that at the end of the rainy season can only be rice. Classification of *lebak* swamp into three categories based on topography and length of puddle time. First, the shallow embankment is a swampy area with relatively high topography and short puddle time. Second, the deep swamp is an area located away from the shallow *lebak* and is a basin that regularly contains water. Third, the central swamp is an area situated between the deep swamp and the shallow embankment (Sulaiman et al., 2019).

Lebak swamp is characterized as always stagnant in the rainy and dry seasons in the dry season. There were three types of *lebak* swamp: 1) shallow *lebak*, in the rainy season with a height of 50 cm for three months, 2) central *lebak*, water level between 50 −100 cm for 3-6 months, and 3) deep puddles for six months. Shallow *lebak* can be planted with rice and other food crops, while the deep *lebak* is only suitable with higher local rice (Suriadikarta and Sutriadi, 2007).

The main problem of swamp swamps is the high flooding in the rainy season and drought in the dry season with flood conditions (Waluyo et al., 2008). In general, farmers can grow rice in this swampland only once a year during the dry season. Rice cultivation is carried out after the water in the swamp begins to recede and is then followed by the central and deep swamps. The use of adaptive rice variety in swampland is one of the essential efforts that need to make higher productivity, resistant to pests and major diseases, and have good rice quality (Suparwoto and Waluyo, 2019).

Causes of low productivity of swampland are low soil fertility, 5-6 months local variety, and conventional land management. The main obstacles in developing swampland are unpredictable inundation and drought and depend on the topography of the hydro, rainfall, and water levels of local rivers (Helmi, 2015). If the evapotranspiration value is higher than the rain, it will cause drought conditions. The amount of evapotranspiration is not affected by rainfall, but by the area of land cover. Rainfall, tides, rivers, and runoff affect water availability (Puspitahati et al., 2017).

The total area of swampland in Indonesia is 13.27 million ha. The new public or private sector is utilizing an area of 4 million ha. A place of 2.6 million ha is managed by the public and private sector, while 1.3 million ha is government assistance (Muhakka et al., 2019). Rice planting on *lebak* swamp is only about 694,291 ha (5%) of a total area of 13.2 million ha. *Lebak* swamp can only be planted rice once in South Sumatra Province (148,979 ha), Central Kalimantan (114,500 ha), and West Kalimantan (102,200 ha). Other Provincial regions average less than 100,000 ha. Lebak swamp that can be cultivated rice twice a year, namely in Riau Province, South Kalimantan, West Kalimantan, and Central Kalimantan with an area of more than 10,000 ha each, but other provinces average less than 10,000 ha. The progress of land use for agricultural businesses is still low, so it still has excellent opportunities as a source of agricultural growth (Sudana, 2005). Swampland of 11.64 million ha is low terrestrial, except in Sumatra, about 0.03 million ha (BPPP, 2019).

The development of tidal swamps for agriculture requires land and water management and technology to get optimal results. The acceleration of agricultural development in tidal swampland can be through four subsystems, namely land development, cultivation development, mechanization, and post-harvest, as well as. The innovation can be used as a foundation to develop the acceleration of agriculture in swampland (Effendi et al., 2014).

Proper water availability control in the tidal swamp can increase the rice-planting period three times a year. The first season will start from November-February to grow rice per year (Wildayana and Armanto, 2018).

In 2012, the area of *lebak* swamp in Lampung Province reached 55,714 ha with a rice productivity level of 5.13 tons/ha and still has the opportunity to be improved. Rice production can be increased through increased land productivity and crop index, reducing yield gaps, and reducing yield losses. This increase in production will have an impact on improving food availability, both regionally and nationally (Pujiharti, 2017).

The use of new superior variety in swampland can increase rice production. *Inpara* and *Inpari* can grow and thrive in shallow and central marshlands. In the shallow swamp, it is better to use drought-tolerant varieties such as *Situbagendit, Limboto, Batutegi, Inpago, Inpari-1, Inpari-4, Inpari-6, Inpari-6,* and *Inpara-5*. In the deep swamp, only once a year can grow rice. The use of superior variety resistant to immersion can use *Inpara-3, Inpara-4*, and *Inpara 5* (Suparwoto and Waluyo, 2019).

Higher rice productivity is produced by *Inpara 1, Inpara 2*, and *Inpara 3* than other swampland rice varieties. Likewise, the *Mekongga* variety can still provide good productivity in lowland swamplands (Helmi, 2015). Rice production of 4.9, 6.8, 6.1, and 7.0 tons/ha of dried grain is produced *by Inpari 15, Inpari 22, Inpari 30*, and *Inpara 4*. The use of *Inpari 22, Inpari 30*, and *Inpara 4* is worth developing as it is financially profitable (Guwat et al., 2015). The optimal fertilizer dose in *lebak* swamp per ha for *Inpara 3* variety is 300 kg urea, 50 kg SP-36, and 150 kg KCl (Rois et al., 2017). Rice production of *Inpari 9* and *Inpara 4* is higher than the *Mekongga* and IR42 variety in *lebak* swamp (Suparwoto, 2019).

8. Conclusions

The island of Java is Indonesia's center of rice production. The conversion of agricultural land to industrial and residential construction declines rice production. It is necessary to expand agricultural sectors outside Java island through the utilization of swampland. Local farmers around the swamp are still low in adopting a superior variety of rice.

Local farmers around the swamp are still low in adopting a superior variety of rice. The local rice variety has low production potential and longevity. The government has developed many rice varieties that are adaptive in the swampland environment. *Inpara* and *Inpari* are a superior variety for swampland. The *Inpara* is more resistant to standing water for tidal swamps, while the *Inpari* is more suitable in *lebak* swamps. The types of rice variety that have been developed by the government have been planted by swamp farmers in several places and have high yields. However, only a few farmers are willing to adopt this technology. Therefore, it is necessary to promote superior rice cultivation to swamp farmers.

The rice cultivation of superior variety in the swamp has provided higher rice production. The use of superior varieties of rice with a shorter lifespan can increase the crop index to three plantings in one year. Hence, it is recommended that all farmers in swamp areas can adopt this superior variety, automatically increases rice productivity, and strengthen national food security.

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Source: BBSDLP (2014) cit. Maftuah et al. (2016)

Fig. 1. Map of swamps distribution in Indonesia

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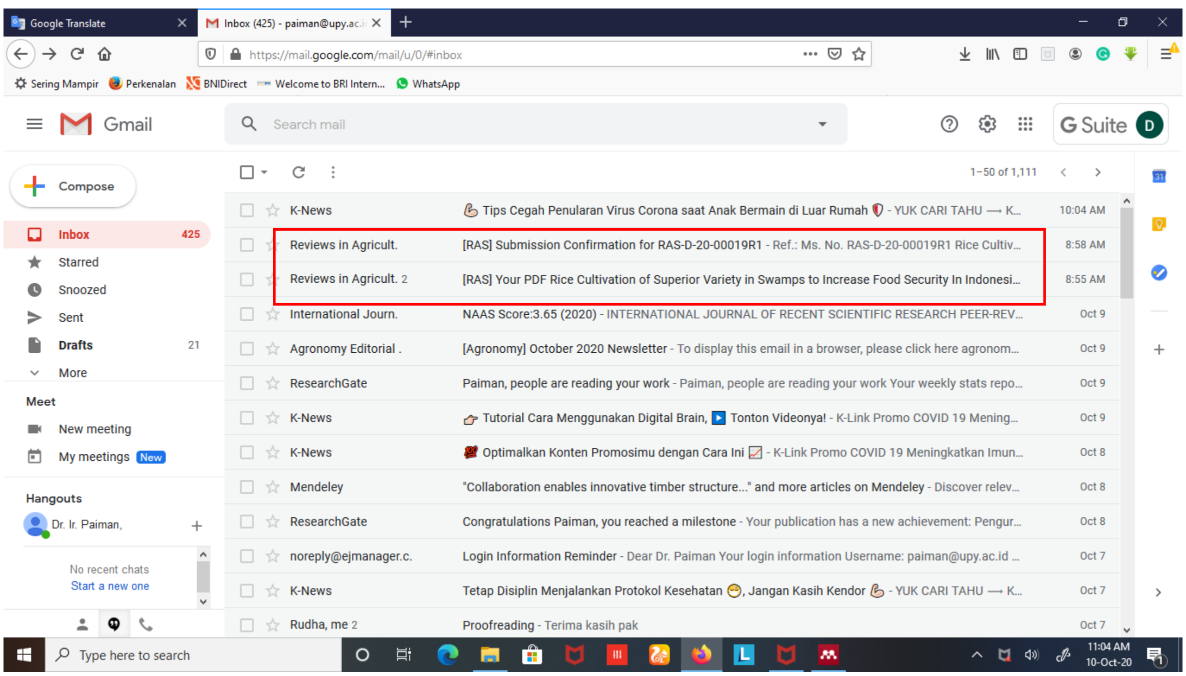

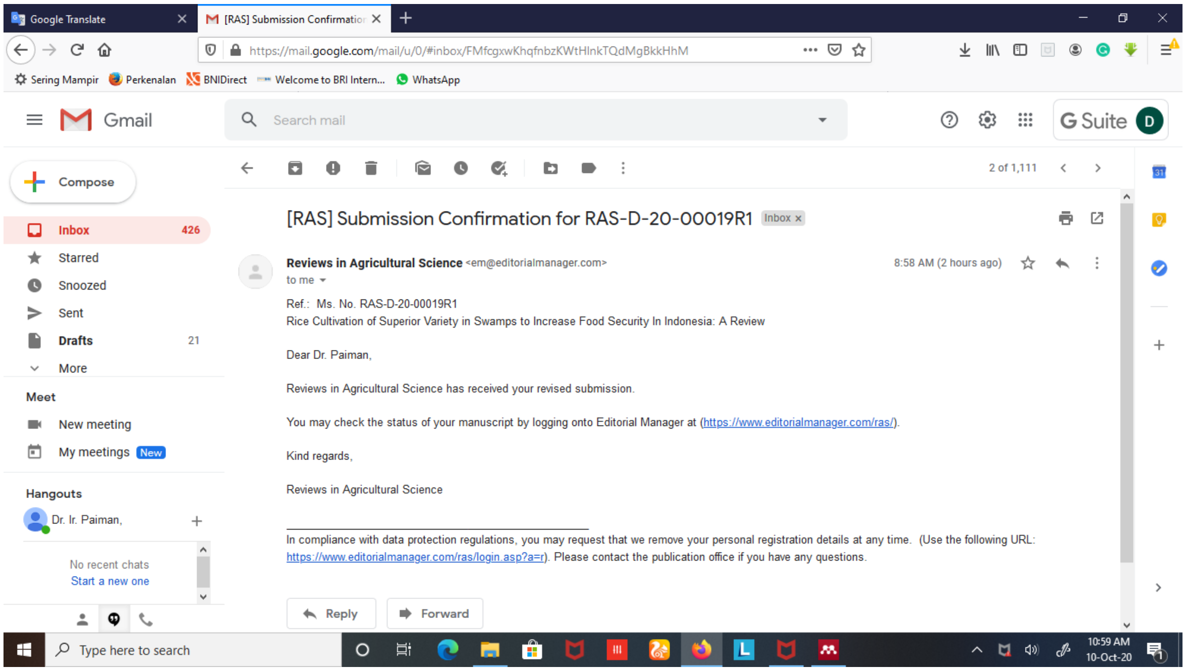

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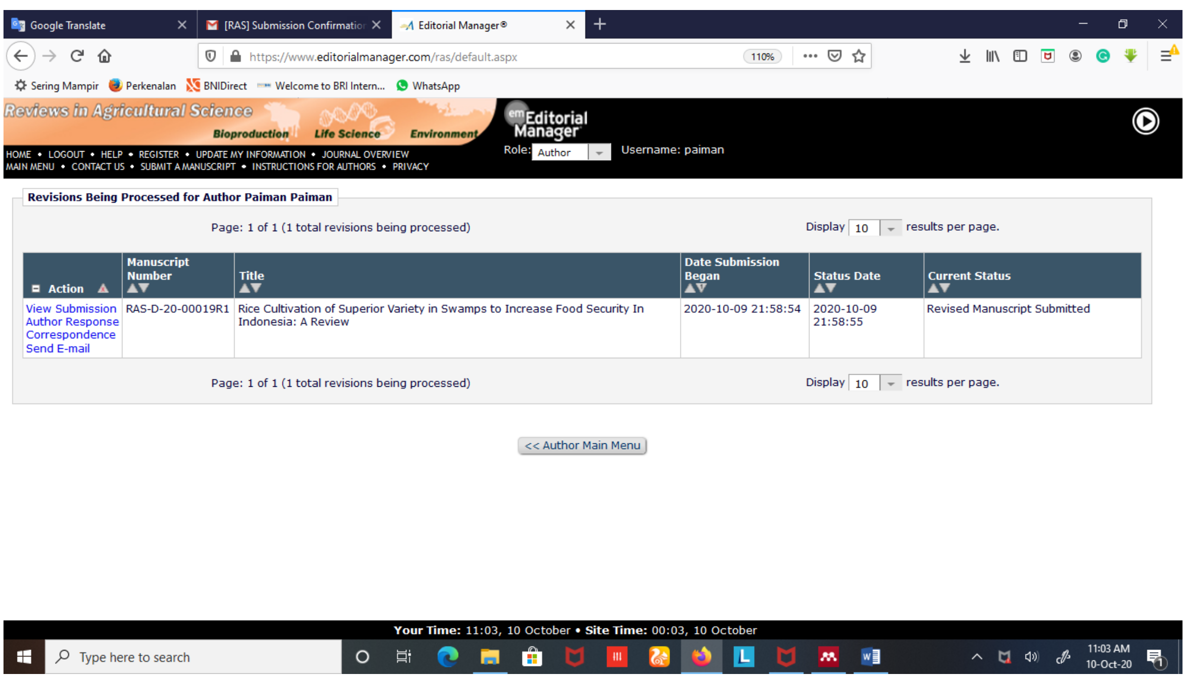

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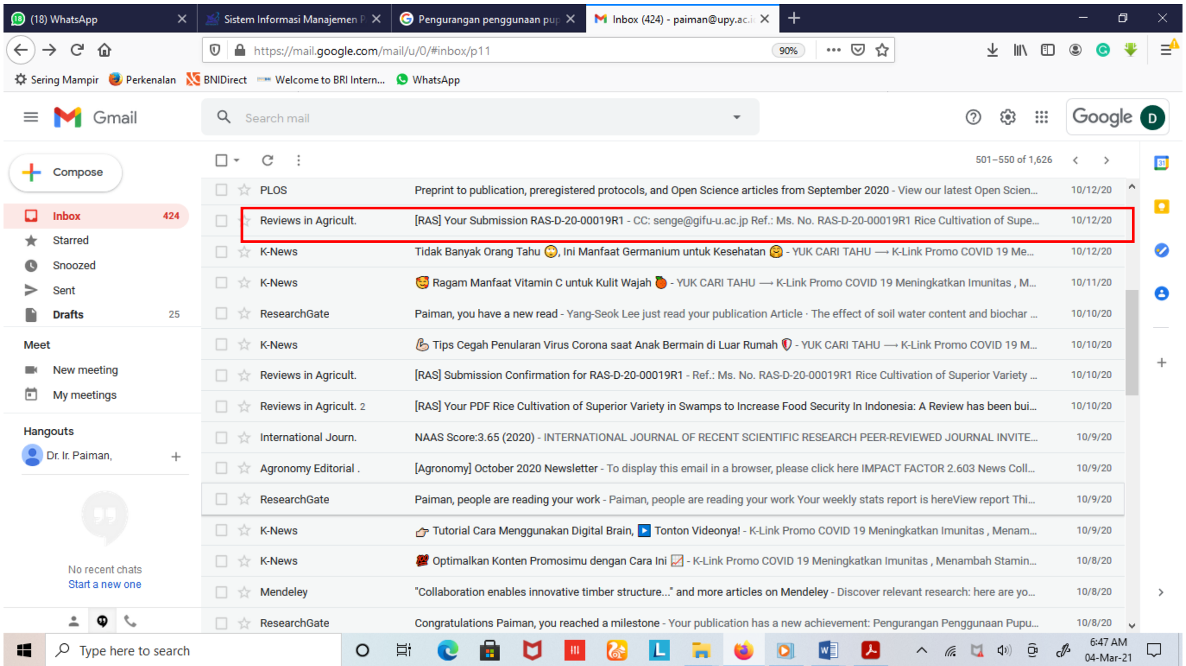
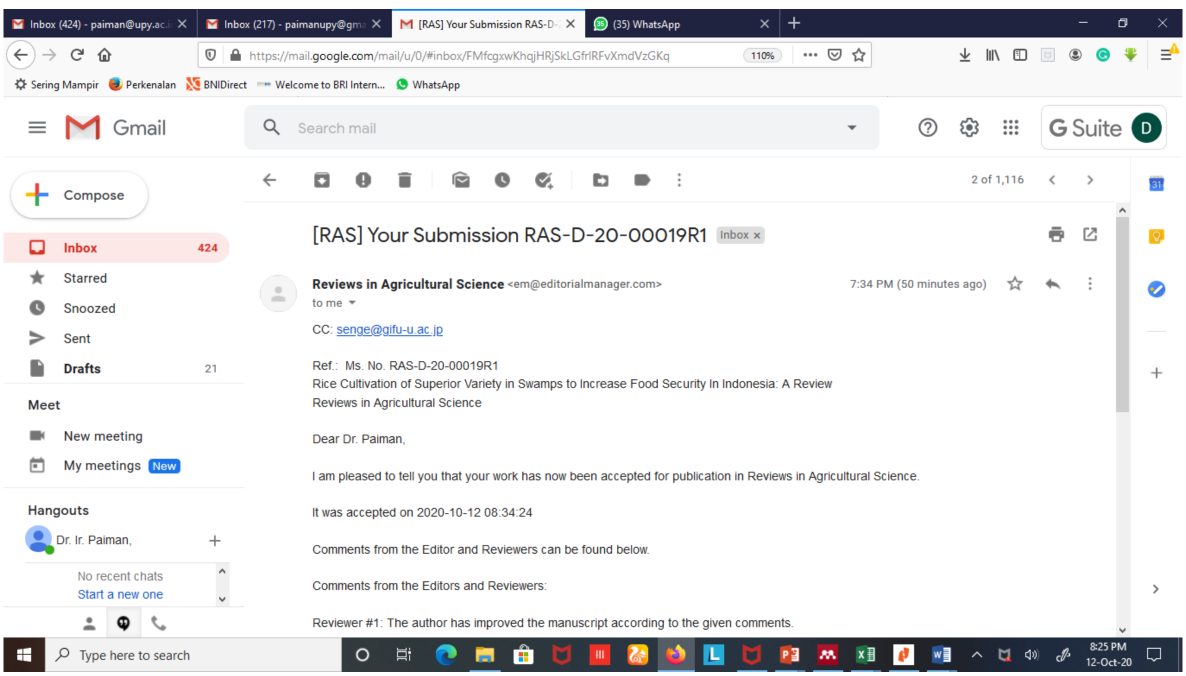
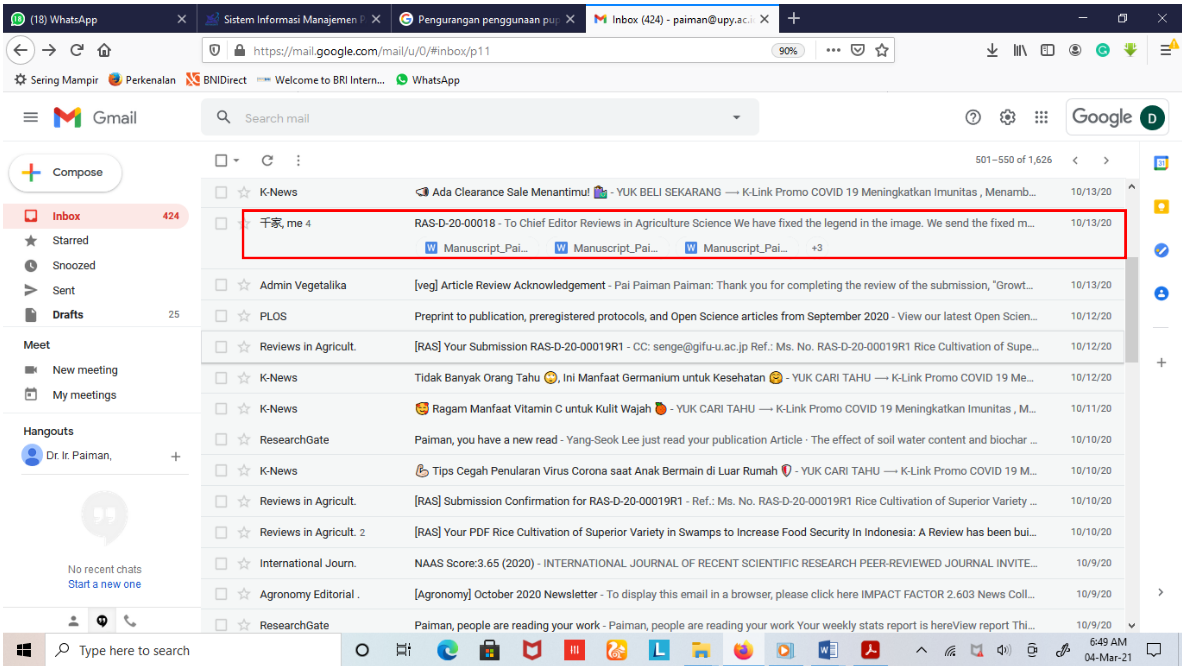
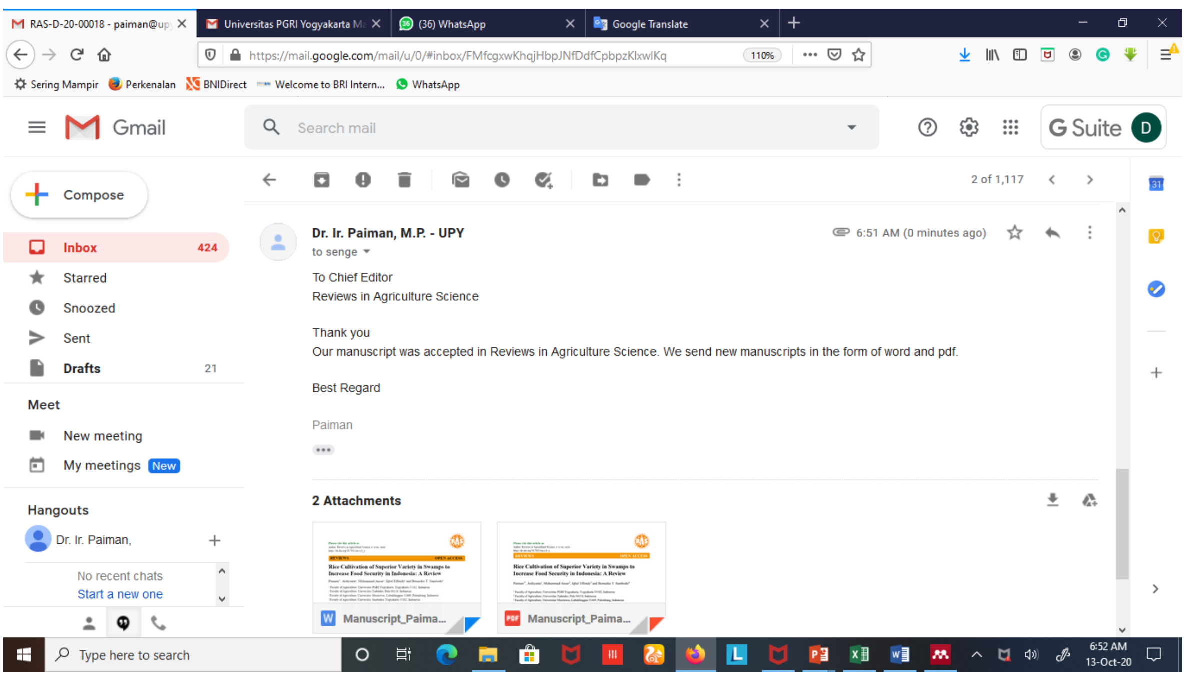




7. Send new manuscript (final) in the form of word and pdf: 13 October 2020





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Rice Cultivation of Superior Variety in Swamps to Increase Food Security in Indonesia: A Review

Paiman[1*], Ardiyanta[1], Muhammad Ansar[2], Iqbal Effendy[3] and Bernadus T. Sumbodo[4]

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ABSTRACT
The island of Java is Indonesia's largest rice production. However, the conversion of land into industrial areas and construction projects has contributed to the decline of rice production on the island. Therefore, it is necessary for the country to expand its agricultural site outside of Java island through the utilization of swampland. Indonesia has large areas of swampland, which have not made the most of it. The swampland farmers have never grown high quality of rice. Thus, the selection of high-quality rice is considered to increase rice production in the swampland. This article aims to discuss the rice cultivation of superior variety in the swamp to improve national food security. The result of this research showed that local farmers in the swamp area rarely adopt high-quality rice. In fact, local rice variety has low productivity and longer lifespan. Therefore, the use of the superior quality of rice is expected to boost rice production. Nevertheless, the Government of Indonesia has developed numbers of high-quality rice such as *Inpara* and *Inpari*, which are more

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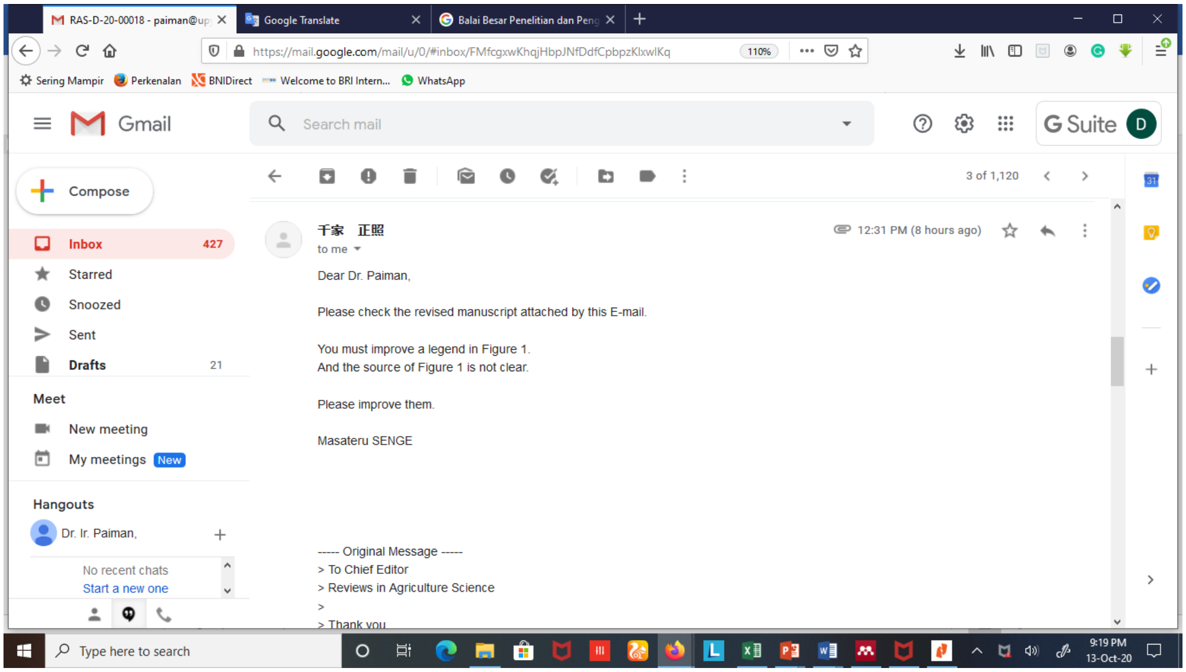
8. Second Revision: 13 October 2020



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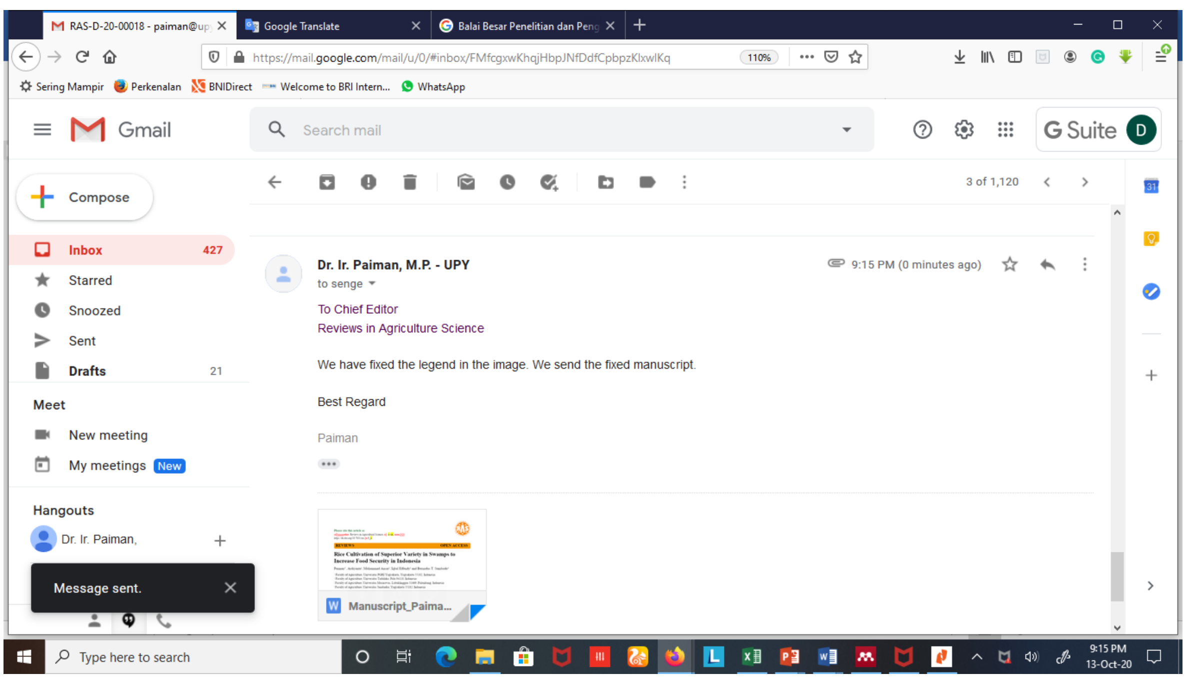

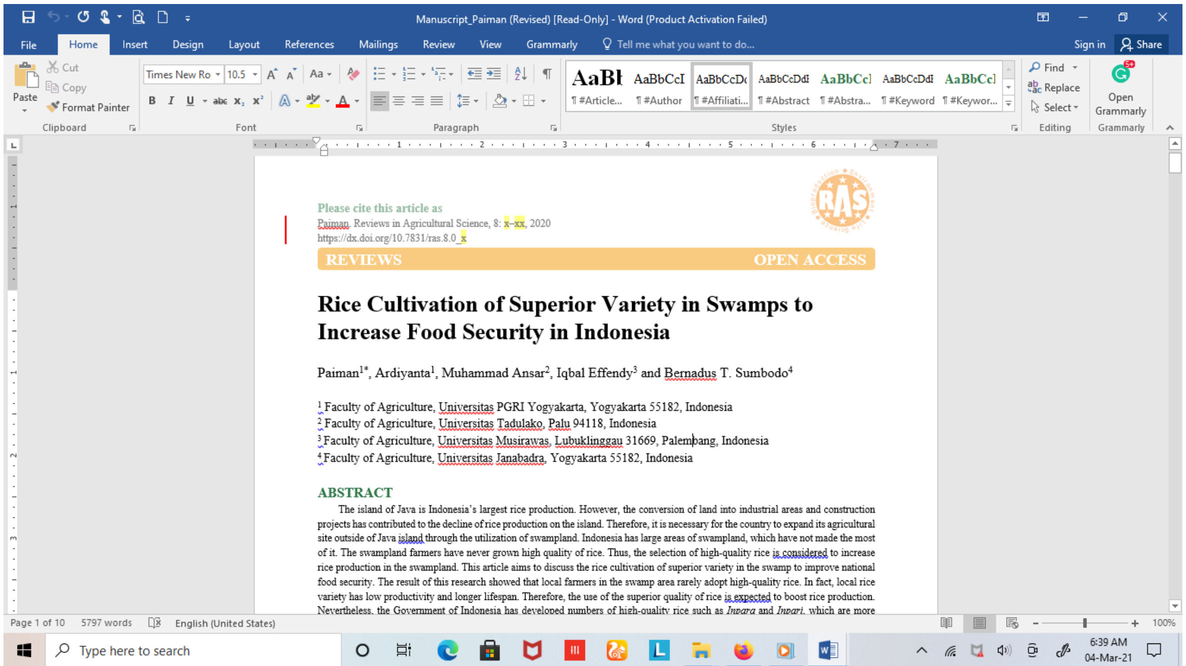

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