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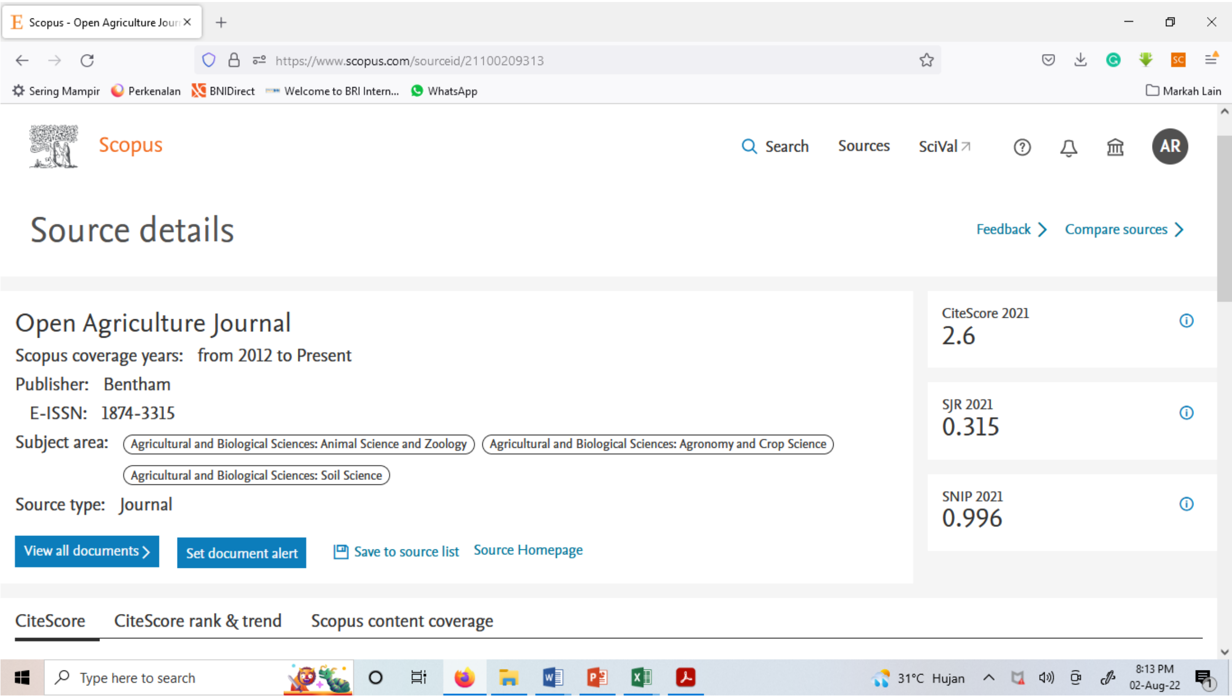

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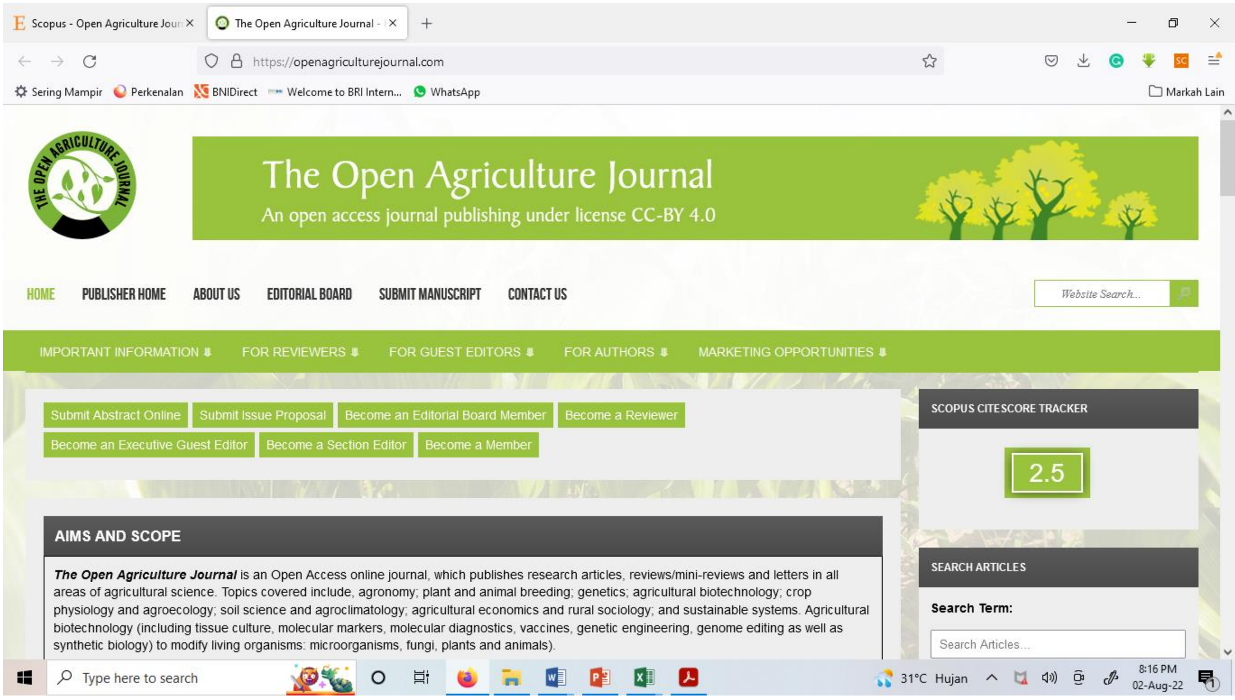

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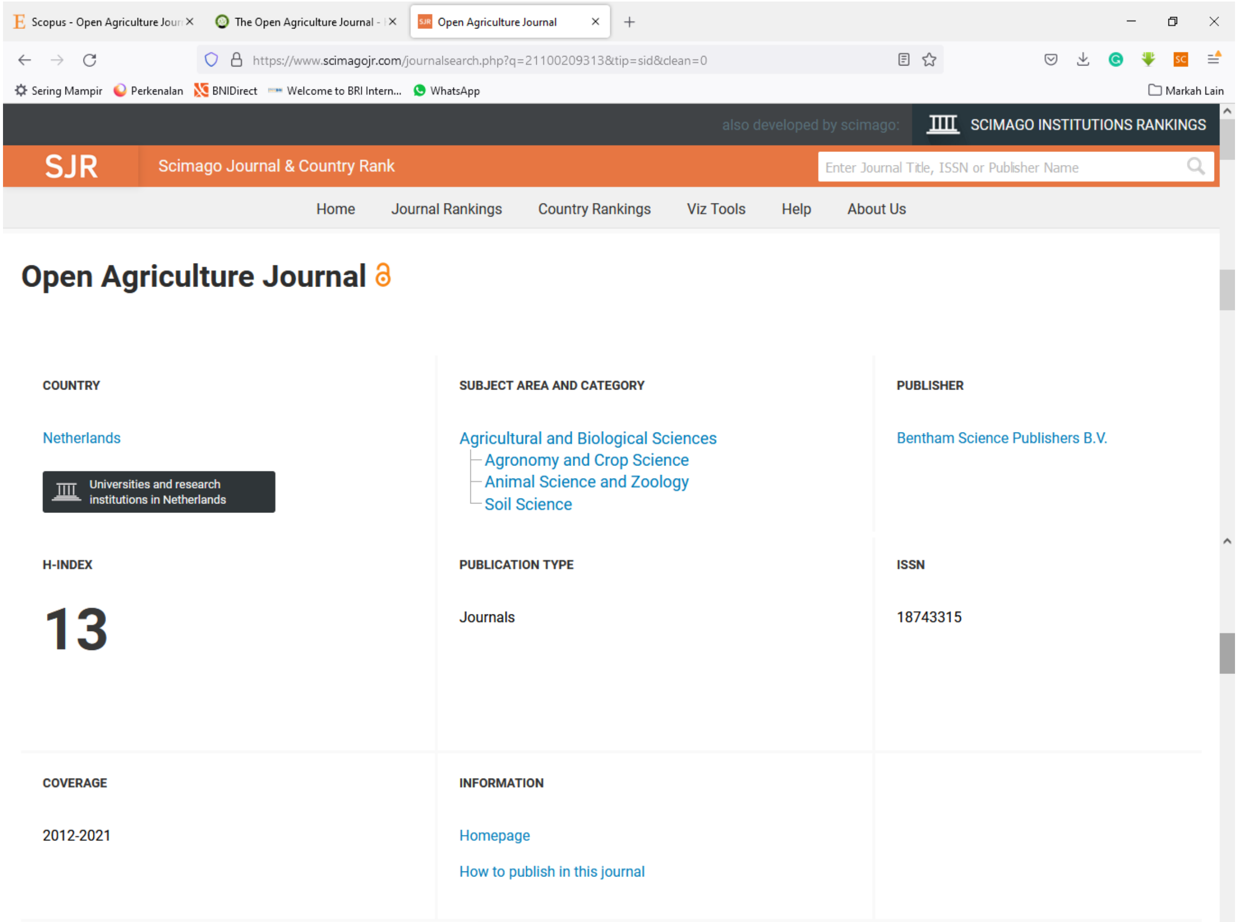

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The role of agronomic factors in salibu rice cultivation

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Abstract:

Background:

Salibu rice cultivation is one of the technologies that have been developed in Indonesia but has not continued. This technology has great potential to increase land productivity. The unsustainability of the SR cultivation due to the low production of the parent rice. Not much is known about the agronomic factors affecting SR cultivation.

Objective:

This review article aims to know the role of agronomic factors in salibu rice cultivation.

Results:

The results of the review article showed that agronomic factors have a major role in SR cultivation. Among the factors have a major role follows. The soil water availability for one year will determine the number of stages of SR cultivation. During 2 weeks before and after harvesting of parent rice, soil water content should be in field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 days after harvest is the right method for SR cultivation. The use of fertilizer dose is carried out according to site-specific recommendations. The first fertilization is given as much as 40% at 15-20 days after stem cuttings and the second fertilization as much as 60% at 30-35 days after cuttings in SR cultivation.

Conclusion:

Among the agronomic factors affecting salibu rice cultivation was the availability of soil water, the time and height of stem cuttings, the dose and time of fertilization. To get the maximum growth and yield of salibu rice, so three agronomic factors need to be considered and applied by farmers.

Keywords: Cultivation, Fertilizer, Parent rice, Superior variety, Salibu rice, Soil water, Stem cuttings.

Running title: Agronomic factors in salibu rice cultivation

1. INTRODUCTION

Various innovations are continuously made to increase national food self-sufficiency and farmers' income. One of the innovations is using salibu rice (SR) cultivation technology. Salibu is an abbreviation from '*salin ibu*' (changes mother in English). The SR cultivation has been developed in various Indonesian regions but has not received a good response from farmers. However, SR cultivation is stagnant in Indonesia. Indeed, SR production is considered lower than the transplanting system (TS). The low production is because farmers do not know the role of agronomic factors affecting the growth and yield of SR.

Rice is a food crop that has been cultivated from generation to generation by Indonesian farming communities. This technology is more efficient in terms of cost and labor than the TS because it does not involve tillage, seeding, and planting. Not many rice farmers understand the benefits of using this technology. The SR cultivation could increase land productivity and farmer income higher along with increased cropping intensity, efficient use of resources, and lower production costs. According to Surdianto and Sutrisna [1], the SR is effective enough to be developed so that farmers have the opportunity to adopt this technology to increase the cropping index (harvest index) and rice production.

The SR cultivation provides hope as a climate-smart technology and resource. The SR provides an opportunity to increase the intensity of harvest per year because the duration of growth is shorter than the parent rice. Besides that, it can be cultivated with less than 50% labor, 60% water availability lower, and production costs lower than the parent rice [2]. The effectiveness of water use in SR cultivation is also higher [3]. This technology is feasible to be developed because it has a benefit-cost ratio > 1. The SR cultivation has a crop maturity period shorter (decreased by 45.66%) so it is a technological breakthrough to anticipate climate change (drought) [4].

According to Erdiman et al. (2013), the harvest age of the main crop could be done 10 days early than TS to be prepared as parent SR. Then, the activity differences others in SR and TS were presented in Table 1.

Table 1. The activity differences in SR and TS cultivation.

Parameter	SR	TS
Land preparation	Stem cuttings after TS harvest	Cleaning the leftover straw
Soil tillage	-	Plowing and harrowing
Nursery	-	Yes
Planting	-	Yes
Fertilization	Following recommendations and increase in N (25-50%)	Following recommendations
Thinning and embroidery	20-25 DAS the parent rice	25-30 days after planting (DAP)
Maintenance	Standard of plant pests	Standard of plant pests
Harvest age	20% earlier than the age of TS harvest	Following harvest age

Remarks: - = No activity

Table 1 shows that the striking difference between SR and TS is that there is no soil tillage, nursey, and planting activities so that they are more efficient in the use of labor. The use of N fertilizer needs to be increased to stimulate vegetative growth because the SR lifespan is shorter. The first and second fertilization was done earlier than the TS. The harvest age of SR is 20% faster than TS.

The SR cultivation has not been much in demand by the farming community because of its low production. The slow development of this technology is due to the lack of information on research results so that farmers do not dare to speculate about trying SR cultivation. A study to know the agronomic factors affecting the growth and yield of SR needs to be done. Thus, it is hoped that SR cultivation can develop again to maintain food in Indonesia. There is a need for a literature review to provide complete information about the right of SR cultivation. This review article aims to know the role of agronomic factors in SR cultivation.

2. SALIBU RICE

The SR was first developed in West Sumatera (Indonesia). The SR is a form of local wisdom-based technology that can solve the increasing need for food in Indonesia. The SR harvest life is shorter than the parent rice, so it is possible to harvest 4 times in one year. The use of appropriate technology for rice harvesting is needed to increase time efficiency (not much time is lost). According to Hasan et al. [6], the application of appropriate technology for rice harvesting in developing countries is urgently needed to increase cropping intensity, crop productivity, and less time, effort, and input costs.

The SR is a modification from ratoon rice. The stem cuttings of the parent rice shorter or closer to the soil surface are more suitable for SR cultivation technology [7]. The SR is a rice plant that grows from the remaining stems that are cut after harvest. New shoots will emerge from the remaining stems near the soil surface and form new roots. Initial growth and the strength of tiller formation depend on the carbohydrate reserves of the stem and root of the parent rice. Furthermore, it is supported by new leaves so that the supply of carbohydrates is no longer dependent on the previous parent plant. The shoots will form new tillers again like transplanted rice.

The growth and yields of SR are influenced largely by rice variety [8]. The superior varieties of seed are more important and beneficial for rice productivity [9]. The selection of parent rice seeds prioritizes superior varieties with high production and short life. The use of short-lived types can increase the cropping index. The use of superior varieties with high production, resistance to pests and diseases, and tolerance to abiotic problems can increase rice yields. According to Bui *et al.* [10], tolerant varieties have higher survival rates and less shoot elongation, but longer root elongation during immersion than sensitive varieties.

The several inbred and hybrid rice have high production and harvest lives shorter in Indonesia, as shown in Table 2.

Table 2. List of superior variety from inbred and hybrid in Indonesia.

Superior varieties	Harvest age (days)	Average yields (ton ha^{-1})	Potential yield (ton ha^{-1})
	Inbred rice		
Inpari 11	105	6,5	8,8
Inpari 13	99	6,6	8,0
Inpari 18	102	6,7	9,5
Inpari 19	104	6,7	9,5
Inpari Sidenuk	103	6,9	9,1
Padjajaran Agritan	105	7,8	11,0
Cakrabuana Agritan	104	7,5	10,2
	Hybrid rice		
Hipa 10	114	8,1	9,4
Hipa 11	114	8,4	10,6
Hipa 12 SBU	105	7,7	10,5
Hipa 13	105	7,7	10,5
Hipa 14	112	8,4	12,1
Hipa 18	113	7,8	10,3
Hipa 19	111	7,8	10,1

Table 2 shows that hybrid rice has production higher than inbred rice. The hybrids in Indonesia have potential high production and shorter harvest age. The hybrid rice of Hipa 10, Hipa 11, and Hipa 14 can be used as the parent rice. These superior varieties as parent rice are expected to reduce high-producing genetic traits. Lardi *et al.* [8] stated that under natural conditions, plant growth is largely determined by the plants' genetic factors, especially the condition of growth regulators (hormones). According to Liu *et al.* [11], SR growth is influenced by the growth of parent rice, so it can be evaluated by determining parent rice-growing conditions.

The yield of grain in SR plants is a complement to the parent rice [12]. The high yield of hybrid rice is due to the increased harvest index. The hybrid yielded significantly higher productivity than those cultivated in the dry season, but the difference was not significant in the wet season. Hybrids produce spikelet panicle^{-1} and 1000 grain dry weight higher than inbred rice [13]. The ratoon yield of the hybrids was better than inbred. The average result was 75.2% of the parent rice [14]. The use of short-lived varieties is more profitable [15]. Ratoon yields were higher using hybrid than inbred rice [16]. Utilization of the hybrid ratoon rice in androgenetic conditions will save cultivation time and costs [17].

Rice production is influenced by some factors, namely varieties, management, and environments. Among the environmental factors were agronomic traits and climate [18]. Land-use efficiency forms must be developed continuously [19]. Land is a key factor in production agriculture [20]. Rice as a perennial crop produced a stable and sustainable grain yield over successive seasons across years [21]. The use of hybrid rice has productivity and profitability higher [22]. Besides, the application of agricultural technology innovation is an important factor to support increased rice production [23]. The efforts of SR cultivation were made to increase land productivity to meet food needs through SR cultivation. Rice crops can be cultivated many times a year by SR cultivation to increase land productivity. Agronomic factors have a big role in increase SR production.

3. AGRONOMIC FACTORS

3.1. Availability of Soil Water

The SR rice allows rice harvests of 3.5–4 times per year with yields equivalent to that of the parent rice [7]. The increases number in the harvest index depending on the water availability conditions. According to Negalur et al. [2], SR has a short growing duration, so it is suitable in rainfed areas with residual soil moisture. Rainfed rice fields can be planted once or twice in harvests, depending on the unpredictable rainwater, and making good planning difficult. Harvesting can be done 3-4 times per year on semi-technical rice fields and technical irrigation. The cropping system patterns of TS (1st stage), SR (2nd stage), and SR (3rd stage) are more profitable than TS (1st stage) and TS (2nd stage) in one year.

The selection of rice varieties is better determined by water conditions in the field [24]. Increasing land productivity is a determining factor for rainfed rice farming [25]. Rice breeders regard ratooning as an important practice for sustainable rice production in tropical agricultural systems to maximize profits [26]. Rainfed land has important benefits in increasing food production. The TS is better than the seed-direct system. There is a time to take advantage of residual soil moisture [15]. Rice cultivation in rainfed lowland can be increased from one to two harvests using the TS (1st stage) and SR (2nd stage) in a year.

The soil moisture content influenced it during the main crop harvest [27]. The inundation height of 5 cm from the soil surface resulted in taller plants and more tillers than the saturated condition treatment with a 0.5 cm water layer [28]. Saturated conditions up to 1 cm in height can easily be applied in rice cultivation by farmers and do not affect rice production and soil characteristics [29]. Ratoon rice yields showed that inundation (full flooding) gave the highest yield than inundation intervals of 2, 4, and 6 days [30].

In contrast to the research results by Elkheir et al. [31] stated that each soil type is essential to conserve water and yields show better rice production under aerobic conditions. According to Bleoussi et al. [32], the protein content of each rice variety increases with increasing drought- intensity. The groundwater deficit has significant implications for grain quality. Momolu [33] stated that grain yields for all rice cultivars decreased with the formation of tillers and theses due to the extended stress period.

The rice field ecosystem is divided into lowlands, highlands, and waters. Rice ratooning is more suitable for lowland rice fields [35]. The SR cultivation can be done on rainfed land, although it can only be done in two stages, namely TS (1st stage), and SR (2nd stage) due to the limited availability of soil water. Barnaby et al. [34] stated that rice plants have a variety of physiological and metabolic strategies in producing tolerance to water stress. It is necessary for rice varieties selection that is adaptable to deficit irrigation production systems or less water.

The model of SR cultivation pattern is presented in Table 3.

Table 3. The model of SR cultivation in rice fields.

Rice fields types	Generation of the rice plant			
	TS (1st generation)	SR (2nd generation)	SR (3rd generation)	SR (4th generation)
Rainfed	ϴ	√	-	-
Semi-technical irrigation	ϴ	√	√	-
Technical irrigation	ϴ	√	√	√

Remarks: ϴ = TS cultivation, √ = SR cultivation, and - = No SR cultivation

Table 3 showed that the availability of soil water for one year will determine the number of stages of SR cultivation that can be carried out. In semi-technical irrigated land, it can be increased to 3 harvests year^{-1} with the pattern, namely the TS (1st stage), SR (2nd stage), and SR (3rd stage). In comparison, on technical irrigated land, it can be increased to 4 rice harvests a year with the pattern, namely the TS (1st stage), SR (2nd stage), SR (3rd stage), and SR (4th stage). The SR could be cultivated more than four times from one planting of parent rice.

3.2. Time and Height of Stem Cuttings

The SR cultivation is better implemented in a land that is not always inundated [37]. During two weeks before and after harvest, soil water content should be in field capacity. Initial shoots growth of SR is better if the soil conditions are moist than inundated. Rice varieties' ability to produce the number of shoots or tillers after cutting the stem of main rice depends on genetic and environmental characteristics, including soil water content availability.

Shiraki et al. [38], stated that soil moisture conditions two weeks before and after the harvest had a significant effect on grain yield. Ratoon plants in dry soil moisture conditions can increase yields by 69% than humid or flood conditions. According to Oda et al. [39] stated that late irrigation is recommended in ratoon rice management practices.

Cutting time of the stem at physiological maturity was given the best ratoon yield [40]. Rice yields are proportional to the number of ratoon tillers produced. The late stem cuttings had the most effect on the ratoon tillers number [39]. The stem cutting shorter causes the ratoon growth to change longer at the vegetative stage of growth and delays the maturity of the grain [41]. Cutting height significantly influences plant height, the number of grains per panicle, and the number of filled grains. Research by Fitri et al. [7] showed that the optimal results for the number of productive tillers, the number of seeds per panicle, and rice productivity are obtained when the remaining stems are cut at the height of 3-5 cm above the soil surface, and carried out at the age of 7-8 days after harvest (DAH).

The main crop's first harvest was done at 5 cm of cutting height [42]. Carbohydrates are needed to maintain metabolic activity during the initial growth stages. The remaining stems provide the energy requirements for new tillers' growth after cutting, and then the tillers immediately become autotrophic [8]. The highest yield of ratoon rice (Ciherang variety) was achieved when cutting stems at harvest with a height of 3 cm above the soil surface with a grain yield of 3.54 tons ha^{-1} [43]. The effect of cutting height on rice yields depends on the photosynthetic conditions and the number of internodes remaining in the main stem as a place for ratoon shoots to appear [44].

There are differences in the differentiation and dynamics of shoot growth at the stem nodes. The morphology of vegetative organs shows that hormones regulate shoot growth on the main stem nodes. There are several proteins involved in brassinosteroid biosynthesis. Brassinosteroid signaling can play a role in the germination of axillary buds of ratoon rice [45]. The ability of rice plants to produce ratoon is strongly influenced by the carbohydrate and phytohormone content left in the stem meristem tissue after harvest [36]. If the stems' cutting is done 2-3 cm from the soil surface, the new shoots that germinate can reproduce to form the next new rice tiller. The difference in the emergence of new shoots on the parent stem could be seen in Fig. 1.

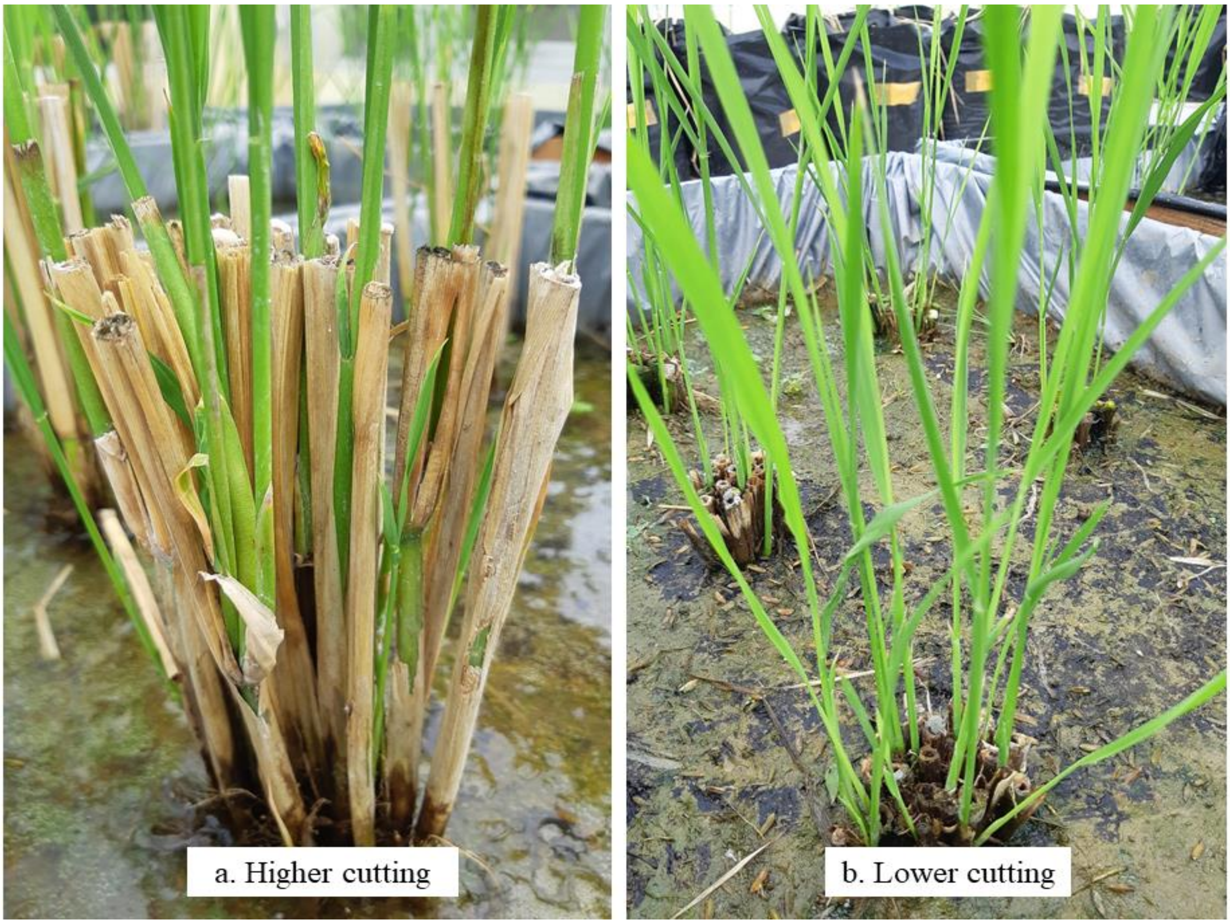

Fig. (1). The emergence of new shoots on the remaining stems with different cuttings height in 14 DAS.

In higher cutting (Fig. 1a), new lateral shoots emerge from the upper stem node. Stem cuttings taller produce more new shoots, and soon new leaf forms. Shoots have short vegetative growth so that the leaves number is small and the leaf area size is narrow, and immediately move into the reproductive phase. In stem cutting lower (Fig. 1b), new shoots grow from the basal stem. The stem cuttings shorter cause new shoots to grow in the soil surface and immediately form new roots then shoots produce new tillers. Rice tillers have a more extended vegetative growth phase and produce more and leaf area broader. The leaf area number affects the photosynthesis process to produce carbohydrates.

The ratoon tillers were related to the level of stem carbohydrates at harvest time [27]. Stem cuttings higher cause the plant to grow and flower quickly because the shoots take advantage of the remaining carbohydrate reserves in the stem of the parent plant. In contrast to stem cuttings shorter, where new shoots are formed that will produce new roots. Furthermore, the new shoots from the next new tillers so that the vegetative life is longer. The research results by Mareza et al. [44] indicate that the stem cuttings lower cause the tiller number clump^{-1} lower and more productive. The number and leaves area tiller^{-1} is more and wider, but the leaf area clump^{-1} is lower. Also, stem cutting shorter resulted in flowering age and harvesting is longer, tillers dry weight higher and the same seed carbohydrate content as the parent plant, but plant dry weight clump^{-1} is lower.

3.3. Dose and Time of Fertilization

The regrowth of tillers depends on the carbohydrate reserves in the plant stems or roots remaining after pruning. The carbohydrates are needed to maintain metabolic activity during the initial stages of regrowth. Energy requirements to supply new tillers immediately become autotrophic [46]. Furthermore, after the shoots grow, it takes a sufficient supply of nutrients from the environment to support normal growth like the previous parent rice. Nutrients in the soil during the harvest of the main crop greatly affect the performance of the shoots.

The growth and yields of SR are primarily influenced by the balanced nutrients [8]. Furthermore, better yields of ratooned crops are possible by increasing fertilization, mainly nitrogen [36]. The SR age is shorter than the parent rice, so there is a need to strengthen its vegetative growth using a balanced fertilization system. Nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) are the primary nutrients for increasing and sustaining SR productivity.

The urea fertilizer application can increase the N element in the soil. The N availability can cause plant leaves to look greener, the number of tillers is more, accelerate the growth of shoots, roots, photosynthesis, and stimulate rice plants' growth. According to Ambarita et al. [47], the excessive N application will inhibit the absorption of other elements so that growth and yield will decrease and increase the amount of empty grain. The research results by

Mamun et al. [48] showed that the use of an additional 25% nitrogen of the recommended dosage for ratoon crops after harvesting the main crop could provide economic yields for hybrid rice.

The dose of 375 kg ha^{-1} urea application increased the number of tillers (32.06 tillers $clump^{-1}$), the number of panicles (18.86 units $clump^{-1}$), and grain dry weight (0.63 kg m^{-2}) in SR cultivation of Ciherang variety [49]. The dose of 50 kg ha^{-1} urea and 50 kg ha^{-1} NPK Phonska fertilizer did not significantly affect rice production between the three zones of high, medium, and lowland on the Salibu system [7]. NPK Phonska is an inorganic fertilizer with the name NPK compound fertilizer consisting of several macronutrients, namely nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). The content of NPK Phonska 15-15-15 is N (15%), P_2O_5 (15%), K (15%), and S (10%). Rice farmers widely use this fertilizer because it can increase yields and grain quality.

An increase in nitrogen dose within a certain range was followed by an increase in leaf area index, plant height, number of tillers, net photosynthesis rate, transpiration rate, and grain yield. In addition, increasing nitrogen dose on grain yield index and nitrogen contribution rate are parabolic [50]. The dosage of nitrogen fertilizer had a different effect on the number of tillers per clump, the percentage of filled grains per panicle, and the weight of 1000 grains [51]. The vegetative age of SR is shorter than the parent plant. Delay in fertilization can lead to fewer tillers and decreased grain yields. Rice plants must absorb sufficient N, P, and K during the growth stage to obtain optimal growth characteristics and yields [52]. Fertilization of SR is carried out according to site-specific recommendations. According to Kristamtini et al. [4] addition that the first fertilization is given as much as 40% of the recommended dose at 15-20 days after stem cuttings (DAS). The second fertilization is done as much as 60% of the recommended dose at 30-35 DAS.

CONCLUSION AND RECOMMENDATION

Based on the review literature above showed that the progress of the development of SR cultivation in Indonesia is very slow, but it can be improved again. Farmers need to apply the agronomic factors that affect the success of SR cultivation. The soil water availability for one year will determine the number of stages of SR cultivation. During 2 weeks before and after harvesting of parent rice, soil water content should be in field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 DAH are the right method for SR cultivation. The use of fertilizer dose is carried out according to site-specific recommendations. The first fertilization is given as much as 40% at 15-20 DAS and the second fertilization as much as 60% at 30-35 DAS. Agronomic factors of the availability of soil water, time and height of the stem cuttings, and the dose and time of fertilization affecting the SR cultivation. Three agronomic factors need to be applied by farmers in SR cultivation.

LIST OF ABBREVIATIONS

DAH	=	Days After Harvest
DAP	=	Days After Planting
DAS	=	Days After Stem Cuttings
N, P, K, S		Nitrogen, Phosphorus, Potassium (K), and Sulfur
SR	=	Salibu Rice
TS	=	Transplanting System

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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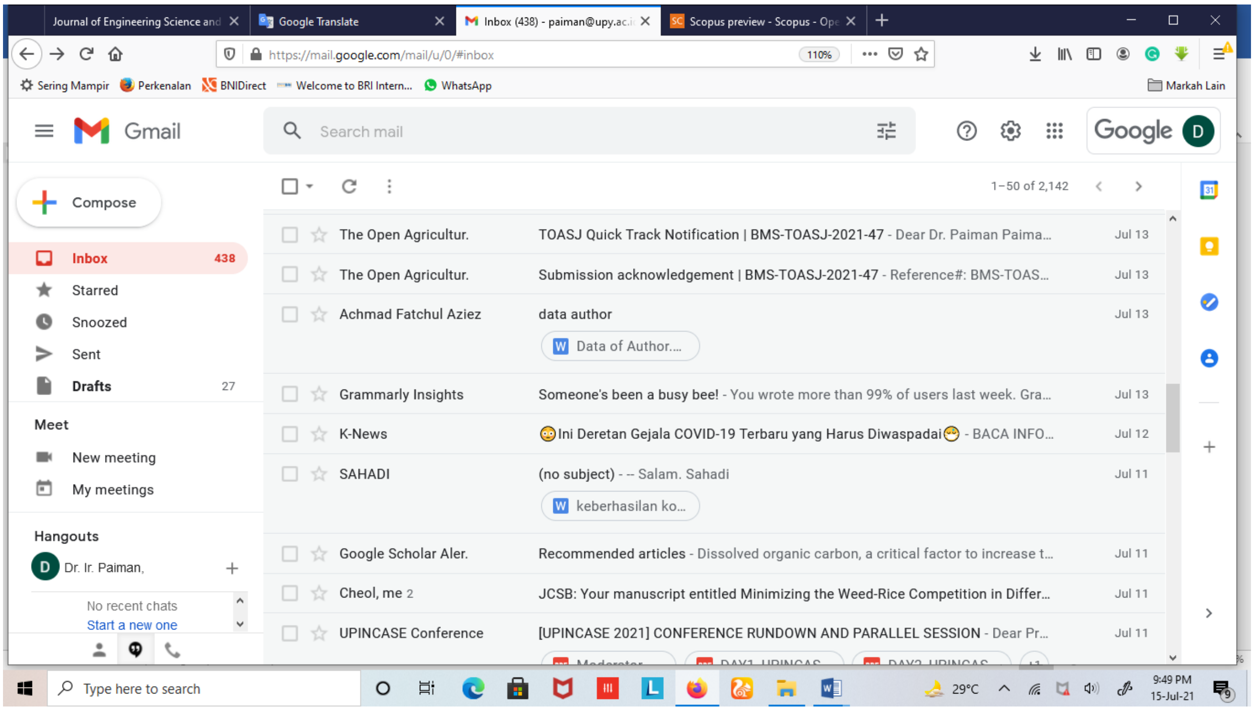

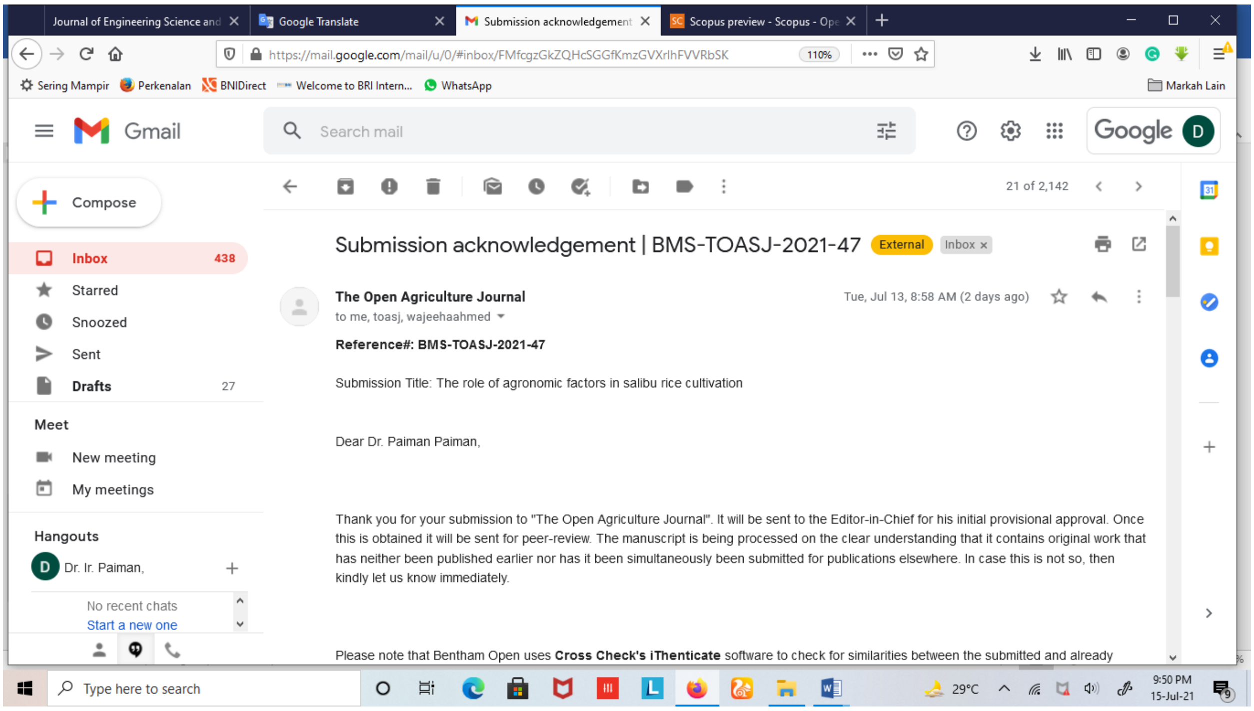

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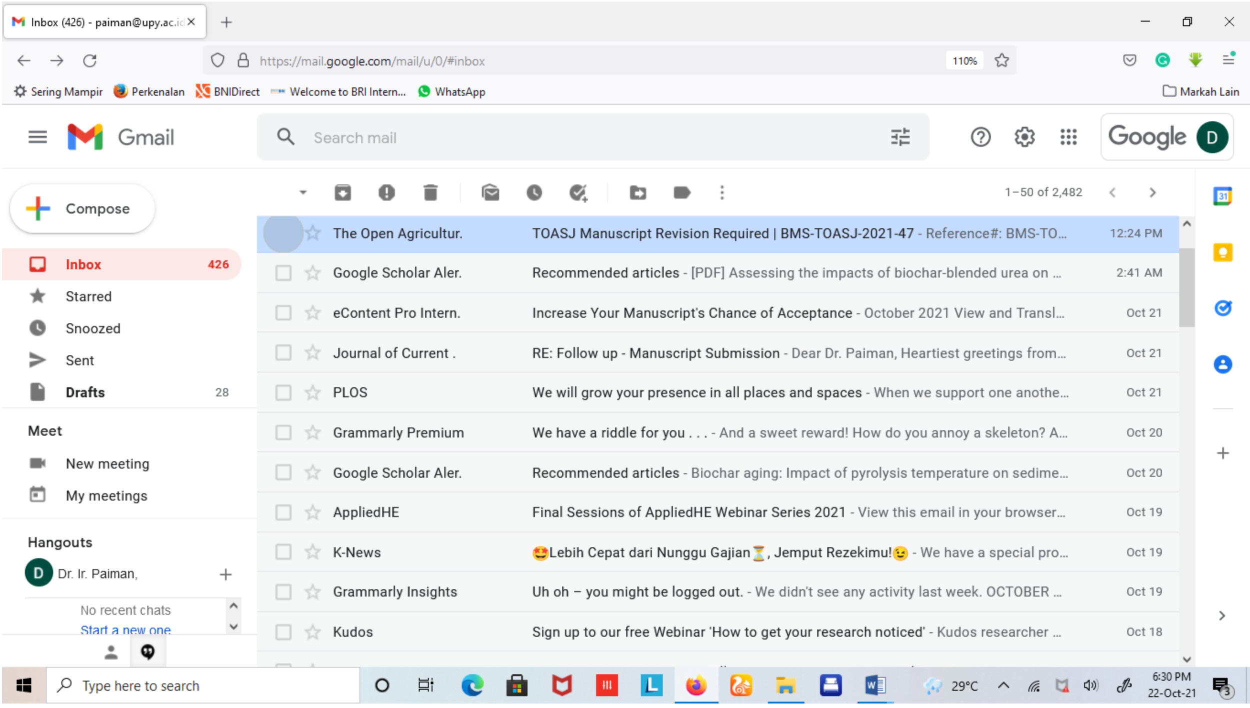
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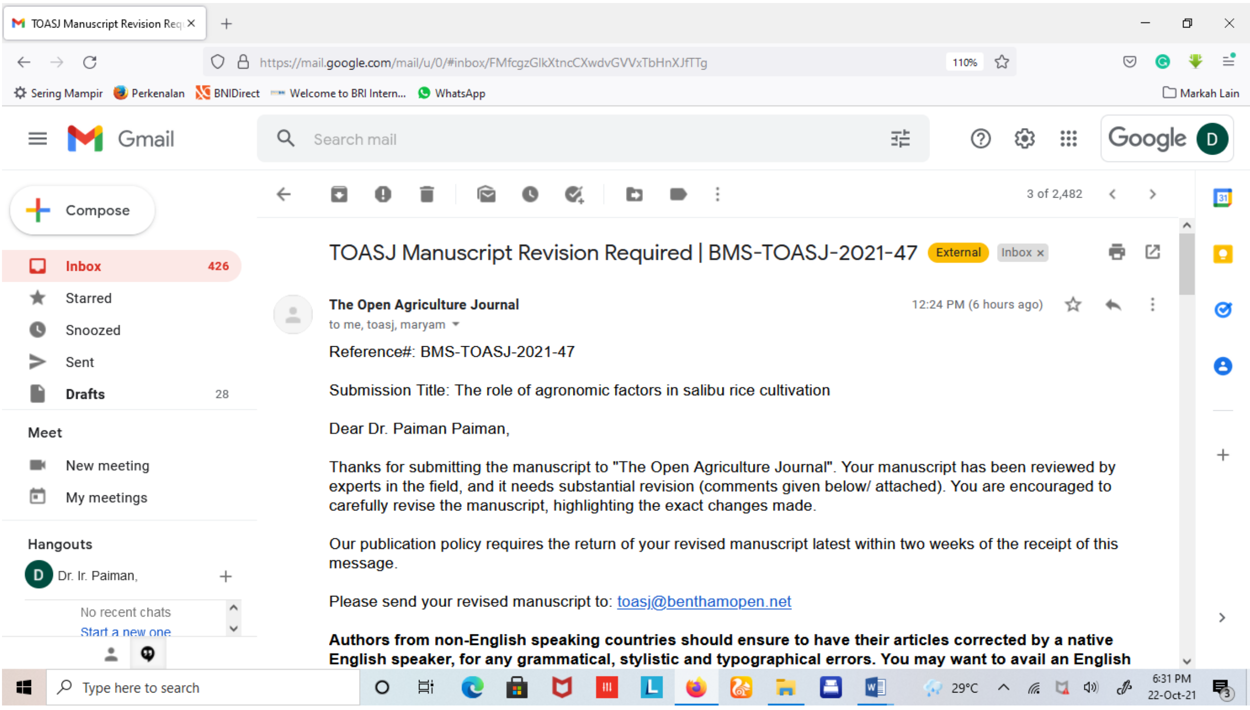
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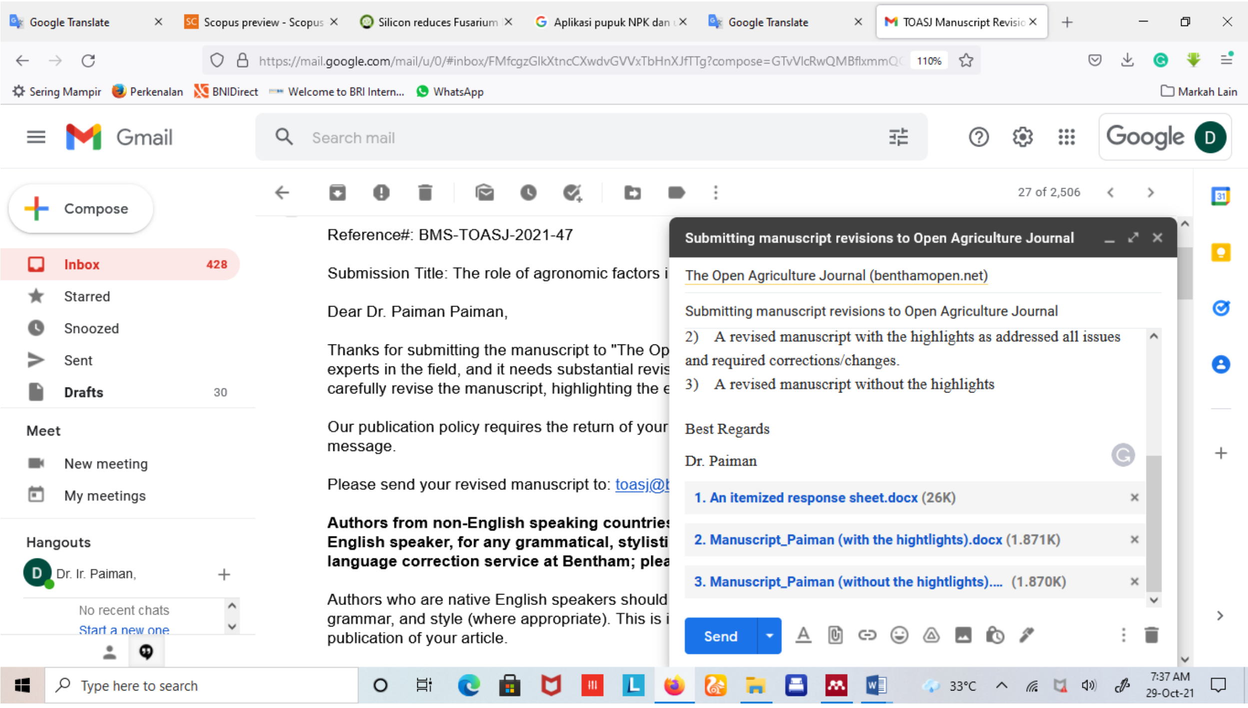

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• Please find the attached STROBE check list and kindly submit filled and signed document along with the revised manuscript	N	• We have found the attached STROBE check list. No humans or animals were used in this research, but used rice crops. So we did not submit filled and signed document.
• When reporting experiments on animals, authors should indicate whether the institution's or a national research council's guide for, or any national law on, the care and use of laboratory animals was followed. When reporting experiments on human subjects, authors should indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, asrevised in 1983.	N	• Our manuscript is not related to animals or humans experiments, so we do not make the Declaration of Compliance with Applicable Standards**.**
Referee 1:		
• The manuscript it is in this scope of the journal, reviewing the role of agronomic factors in salibu rice cultivation for the Indonesian condition. • Page 2, line 7 - … Erdiman et al. [5] … • Page 2, Table 1 – please add as footnote the meaning of SR and TS. • Page 7, section 3.3 - please add a table in the section 3.3 summarizing the rate and time of fertilization needs referred in this section. • Page 7 - please add a proper discussion, including a table, about the comparison of costs among SR and TS rice systems.	Y Y Y Y Y	• Thank you • We have fixed the typing error (5) by [5] in page 2, line 7. • We have added notes in below the Table 1 about the meaning of SR and TS. • We have added Table 4 in the section 3.3 as summarizing the rate and time of fertilization. • We have added proper discussion and Table 5, about the comparison of costs among SR and TS rice systems in page 7.
Referee 2:		
• In previous works, agricultural analysis is often used by the researchers, and Salibu cultivation is a technological that can increase rice production and productivity by increasing the frequent of plantations. I think this paper can publish The Open Agriculture Journal if the authors read and rewrite carefully their text. • Pg. 1: 1. Introduction Line 4: Rewrite "... response from farmers. However, SR cultivation ..." by "... response from farmers. As a result, SR cultivation …".	Y Y Y	• Thank you. We have carefully read and rewrite our text to correct any that are not appropriate. • We have rewritten the addition of the word: "However, SR cultivation…." in page 1, line 3, and: "As result, SR cultivation……" in page 1, line 4.

• Pg. 2: Table 1: TS column: What are the recommendations? Would be follow specific recommendations?	Y	• The dose of fertilizer is adjusted to the specific recommendations of each area of SR cultivation. We have added the word: 'of site-specific' after the word recommendations in page 2, Table 1, in SR and TS column.
• Rewrite "…SR and TS is that there is no soil tillage, nursey, and planting…" by "…SR and TS is that there is no soil tillage, nurture and, planting..."	Y	• We've fixed the wrong word: nursey. The correct word is seeding.
• Pg. 3: Change "dot" by "commas". For example: "6,5" by '6.5"	Y	• We have changed "dot" by "commas" in Table 2: Average yield and potential yields column.
• Pg. 7: References: I could not find this reference: [1] Surdianto Y, Sutrisna N. Performance of Salibu rice farming technology on irrigated sawah areas in Cianjur District. CR J. 2019; 5(2): 75–84.	Y	• The references: Surdianto et al. [1] have revised and located in page 1, paragraph 2, line 5 in the introduction.
• Correct the author's name: Erdiman, Nieldalina, dan Misran		• We have corrected the author's name: Erdiman, Nieldalina, and Misran

2. Manuscript with the Highlights

The Role of Agronomic Factors in Salibu Rice Cultivation

Paiman[1,*], Bambang H. Isnawan[2] , Achmad F. Aziez[3] , Subeni[4] , and Monsuru A. Salisu[5]

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Abstract:

Background:

Salibu rice cultivation is one of the technologies that have been developed in Indonesia but has not continued. This technology has great potential to increase land productivity. The unsustainability of the salibu rice cultivation is due to the yield lower than the parent rice. Not many famers are know of the agronomic factors that can increase the growth and yield of salibu rice.

Objective:

This review article aims to know the role of agronomic factors in salibu rice cultivation.

Results:

The ~~results of the~~ review article showed that agronomic factors had a major role in salibu rice cultivation. Among the factors had a major role follows. The soil water availability for one year ~~will~~ would be determined by the number of stages of SR cultivation. ~~During t~~Two weeks before and after harvesting ~~of~~ parent rice, soil water content should have ~~be~~ been cultivated in field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 days after harvest w~~as the right method for SR cultivation~~ere the right SR cultivation methods. The use of fertilizer dose was carried out according to site-specific recommendations. The first fertilization was given as much as 40% at 14-21 days after stem cuttings, and the second ~~fertilization~~ was as much as 60% at 30-40 days after stem cuttings in salibu rice cultivation.

Conclusion:

Among the agronomic factors affecting salibu rice cultivation are soil water availability, the time and height of stem cuttings, the dose and time of fertilization. Three agronomic factors need to be considered and applied by farmers ~~To~~ to get the maximum growth and yield of salibu rice.~~,~~ ~~so three agronomic factors need to be considered and applied by farmers.~~

Keywords: Cultivation, Fertilizer, Parent rice, Superior variety, Salibu rice, Soil water, Stem cuttings.

Running title: Agronomic factors in salibu rice cultivation

4. INTRODUCTION

Various innovations are continuously made to increase national food self-sufficiency and ~~farmers'~~ farmers' income. One of the innovations is using salibu rice (SR) cultivation technology. Salibu is an abbreviation from '*salin ibu*' (change parent in English). However, SR cultivation has been developed in various Indonesian regions but has not received a good response from farmers. As a result, SR cultivation is stagnant in Indonesia. Indeed, SR production is considered lower than the transplanting system (TS). The low production is because farmers do not know the role of agronomic factors affecting the growth and yield of SR.

Rice is a food crop that has been cultivated from generation to generation by Indonesian farming communities. This technology is more efficient in ~~terms of~~ cost and labor than the TS because it does not involve tillage, seeding, and planting. Not many rice farmers understand the benefits of using this technology. The SR cultivation can ~~be increased land productivity and farmer income higher~~increase land productivity and farmer income, ~~along with increased~~increase cropping intensity, efficient use of resources, and lower production costs. According to Surdianto et al. [1], the SR was effective enough to be developed so that farmers had the opportunity to adopt this technology to increase the cropping index (harvest index) and rice production.

The SR cultivation provided hope as a climate-smart technology and resource. The SR provided an opportunity to increase ~~the intensity of harvest~~harvest intensity per year because the growth duration was shorter than the parent rice. Besides~~ that~~, it can be cultivated with less than 50% labor, 60% water availability lower, and production costs lower than the parent rice [2]. The effectiveness of water use in SR cultivation was also higher [3]. This technology was feasible to be developed because it ~~has~~ had a benefit-cost ratio > 1. The SR cultivation had a crop maturity period shorter (decreased by 45.66%), so it was a technological breakthrough to anticipate climate change (drought) [4].

According to Erdiman et al. [5], the harvest age of the main crop ~~can~~ could be done ~~10~~ ten days early than TS to be prepared as parent SR. Then, the activity differences others in SR and TS are presented in Table **1**.

Table 1. The activity differences in SR and TS cultivation.~~,~~

Activity	Cultivation system	
	SR	TS
Land preparation	Stem cuttings after TS harvest	Cleaning the leftover straw
Soil tillage	-	Plowing and harrowing
Seeding	-	Yes
Planting	-	Yes

Fertilization	Following recommendations of site-specific and increase in N (25-50%)	Following recommendations of site-specific
Thinning and embroidery	20-25 days after stem cuttings (DASC) of parent rice	25-30 days after planting (DAP)
Maintenance	Standard of plant pests	Standard of plant pests
Harvest age	20% earlier than the age of TS harvest	Following harvest age

Remarks: - = No activity, SR = Salibu rice, and TS = Transplanting system.

Source: Erdiman et al. [5].

Table **1** shows that ~~the difference of~~ the difference in activities between SR and TS ~~was there were~~have no soil tillage, seeding, and planting~~,~~ so SR ~~was~~ is more efficient in ~~the use of~~using labor. ~~The use of~~ N fertilizer ~~needed to~~should be increased to stimulate vegetative growth because the SR lifespan ~~was~~ is shorter. The first and second fertilization ~~was~~ is done earlier than the TS. The harvest age of SR ~~was~~ is 20% faster than TS.

The SR cultivation has not been much in demand by the farming community because of its low production. The slow development of this technology was due to the lack of information on research results so that farmers did not dare to speculate about trying SR cultivation. A study to know the agronomic factors affecting the growth and yield of SR needs to be done. Thus, ~~it was hoped that~~ SR cultivation ~~can~~ could be developed again to maintain food in Indonesia. ~~There was a need for a~~A literature review is necessary to provide complete information about the right of SR cultivation. This review article aims to know the role of agronomic factors in SR cultivation.

5. SALIBU RICE

The first~~,~~ SR was developed in West Sumatera (Indonesia). ~~The~~ SR ~~was~~ is a form of local wisdom-based technology that can ~~be solved~~solve the increasing need for food in Indonesia. ~~The SR~~Its harvest life ~~was~~ is shorter than the parent rice, so it ~~was~~ is possible to harvest ~~4~~ four times in one year. ~~The use of a~~Appropriate technology for rice harvesting ~~was~~ is needed to increase time efficiency (not much time was lost). According to Hasan et al. [6], the application of appropriate technology for rice harvesting in developing countries ~~was~~ is urgently needed to increase cropping intensity, crop productivity, and less time, effort, and input costs.

~~The S~~SR is a modification of rice cultivation from ratoon rice. The stem cutting of the parent rice shorter or closer to the soil surface ~~were~~ are more suitable for SR cultivation technology [7]. ~~The S~~SR ~~is a rice plant that~~ grows from the remaining stems that are cut after harvest. New shoots will emerge from the remaining stems near the soil surface and form new roots. Initial growth and the strength of tiller formation depend on the carbohydrate reserves of the stem and root of the parent rice. Furthermore, it ~~was~~ is supported by new leaves so that the supply of carbohydrates ~~was~~ is no longer dependent on the previous parent plant. The shoots will form new tillers again like TS.

The growth and yields of SR ~~were~~ are influenced largely by rice variety [8]. The superior varieties of seed ~~were~~ are more important and beneficial for rice productivity [9]. The selection of parent rice seeds prioritized superior varieties with high production and short life. ~~The use of s~~Short-lived types can ~~be increased~~increase the cropping index. ~~The use of s~~Superior varieties with high production, resistance to pests and diseases, and tolerance to abiotic problems can be increased rice yields. According to Bui *et al.* [10], tolerant varieties ~~had~~ have higher survival rates and less shoot elongation~~,~~ but longer root elongation during immersion than sensitive varieties.

According to Sastro et al. [11], the several inbred and hybrid rice ~~had~~ have high production and harvested lives shorter in Indonesia, ~~high production and harvest lives shorter in Indonesia is~~and the superior rice varieties are shown in Table **2**.

Table 2. List of superior variety from inbred and hybrid in Indonesia.

Superior varieties	Harvest age (days)	Average yields (ton ha^{-1})	Potential yield (ton ha^{-1})
Inbred rice:			
Inpari 11	105	6.5	8.8
Inpari 13	99	6.6	8.0
Inpari 18	102	6.7	9.5
Inpari 19	104	6.7	9.5
Inpari Sidenuk	103	6.9	9.1
Padjajaran Agritan	105	7.8	11.0
Cakrabuana Agritan	104	7.5	10.2
Hybrid rice:			
Hipa 10	114	8.1	9.4
Hipa 11	114	8.4	10.6
Hipa 12 SBU	105	7.7	10.5
Hipa 13	105	7.7	10.5

Hipa 14	112	8.4	12.1
Hipa 18	113	7.8	10.3
Hipa 19	111	7.8	10.1

Source: Sastro et al. [11].

Table **2** shows that hybrid rice ~~had~~ has production higher than inbred rice. The hybrids in Indonesia ~~had~~ have potential high production and shorter harvest age. The hybrid rice of Hipa 10, Hipa 11, and Hipa 14 can be used as the parent rice. These superior varieties, as parent rice, ~~were~~ are expected to reduce high-producing genetic traits. Lardi *et al*. [8] stated that under natural conditions, plant growth ~~was~~ is largely determined by the ~~plants'~~ plants' genetic factors, especially the condition of growth regulators (hormones). According to Liu *et al*. [12], SR growth ~~was~~ is influenced by the growth of parent rice, so it can be evaluated by determining parent rice-growing conditions.

The yield of grain in SR plants ~~was~~ is a complement to the parent rice [13]. The high yield of hybrid rice ~~was~~ is due to the increased harvest index. The hybrid is yielded significantly higher productivity than those cultivated in the dry season, but the difference ~~was~~ is not significant in the wet season. Hybrids produce ~~d~~ spikelet panicle^{-1} and 1000 grain dry weight higher than inbred rice [14]. The ratoon yield of the hybrids ~~was~~ is better than inbred. The average result was 75.2% of the parent rice [15]. ~~The use of s~~Short-lived varieties ~~was~~ are more profitable [16]. Ratoon yields ~~were~~ are higher using hybrid than inbred rice [17]. Utilization of the hybrid ratoon rice in androgenetic conditions will be saved cultivation time and costs [18].

Rice production ~~was~~ is influenced by some factors, ~~namely~~ such as varieties, management, and environments. Among the environmental factors ~~were~~ are agronomic traits and climate [19]. Land-use efficiency forms must be developed continuously [20]. ~~The l~~The land ~~was~~ is a key factor in production agriculture [21]. Rice as a perennial crop ~~produced~~ produces a stable and sustainable grain yield over successive seasons across years [22]. ~~The use of h~~Hybrid rice had productivity and profitability higher [23]. Besides, ~~the application of agricultural technology innovation was an important factor to support~~agricultural technology innovation is an important factor in supporting increased rice production [24]. The efforts of SR cultivation ~~were~~ are made to increase land productivity to meet food needs through SR cultivation. Rice crops can be cultivated many times a year by SR cultivation to increase land productivity. Agronomic factors ~~had~~ have a big role in increasing SR production.

6. AGRONOMIC FACTORS

6.1. Availability of Soil Water

~~The~~ SR ~~allowed~~ allows rice harvests of 3.5–4 times year^{-1} with yields equivalent to the parent rice [7]. The increasing number in the harvest index depends on the water availability conditions. According to Negalur et al. [2], SR ~~had~~ has a short growing duration, ~~so it was~~ suitable in rainfed areas with residual soil moisture. Rainfed rice fields can be planted once or twice in harvests, ~~depending on the unpredictable rainwater, and making good planning difficult~~making planning difficult depending on the unpredictable rainwater. Harvesting can be done 3-4 times year^{-1} on semi-technical rice fields and technical irrigation. The cropping system patterns of TS (1st stage), SR (2nd stage), and SR (3rd stage) ~~were~~ are more profitable than TS (1st stage) and TS (2nd stage) in one year.

The selection of rice varieties ~~was~~ is better determined by water conditions in the field [25]. Increasing land productivity ~~was~~ is a determining factor for rainfed rice farming [26]. Rice breeders ~~regarded~~ regard ratooning as an important practice for sustainable rice production in tropical agricultural systems to maximize profits [27]. Rainfed land ~~had~~ has important benefits in increasing food production. ~~The~~ TS ~~was~~ is better than the seed-direct system. There ~~was~~ is a time to take advantage of residual soil moisture [16]. Rice cultivation in rainfed lowland can ~~be increased~~increase from one to two harvests using the TS (1st stage) and SR (2nd stage) in a year.

The soil moisture content ~~influenced~~ influences the main crop harvest [28]. The inundation height of 5 cm from the soil surface ~~resulted~~ results in plants taller and more tillers than the saturated condition treatment with a 0.5 cm water layer [29]. Saturated conditions up to 1 cm in height can be applied in rice cultivation by farmers and ~~did~~ do not affect rice production and soil characteristics [30]. Ratoon rice yields ~~showed~~ show that inundation (full flooding) ~~gave~~ gives the highest yield than inundation intervals of 2, 4, and 6 days [31].

In contrast to ~~the research results by~~ Elkheir et al. [32], ~~stated that~~ each soil type ~~was~~ is essential to conserve water, and yields show better rice production under aerobic conditions. According to Bleoussi et al. [33], the protein content of each rice variety ~~increased~~ increases with increasing drought- intensity. The groundwater deficit ~~had~~ has significant implications for grain quality. Momolu [34] stated that grain yields for all rice cultivars ~~decreased~~ decrease with the formation of tillers and theses due to the extended stress period.

The rice field ecosystem ~~was~~ is divided into lowlands, highlands, and waters. Rice ratooning ~~was~~ is more suitable for lowland rice fields [35]. The SR cultivation can be done on rainfed land, although it can be done in two stages, ~~namely~~ TS (1st stage), and SR (2nd stage), due to the ~~the limited availability of soil water~~limited availability of soil water. Barnaby et al. [36] stated that rice plants ~~had~~ have a variety of physiological and metabolic strategies in producing tolerance to water stress. It ~~was~~ is necessary for rice varieties selection that ~~was~~ is adaptable to deficit irrigation production systems or less water. The model of SR cultivation pattern is presented in Table **3**.

Table 3. The model of SR cultivation in rice fields.

Rice fields types	**Generation of the rice plant**			
	TS (1st generation)	**SR (2nd generation)**	**SR (3rd generation)**	**SR (4th generation)**
Rainfed land	ϴ	√	-	-
Semi-technical irrigated	ϴ	√	√	-
Technical irrigated	ϴ	√	√	√

Remarks: TS = Transplanting system, SR = Salibu rice, ϴ = TS cultivation, √ = SR cultivation, and - = No cultivation.

Table **3** ~~showed~~ shows that ~~the availability of soil water~~soil water availability for one year will ~~be determined the number of stages of SR cultivation~~determine the number of SR cultivation stages ~~that can be carried out~~. In semi-technical irrigated land, it can be increased to 3 harvests year^{-1} with the patterns,~~, namely the~~ TS (1st stage), SR (2nd stage), and SR (3rd stage). In comparison, on technical irrigated land, it can be increased to 4 rice harvests a year with the pattern~~, namely~~s, the TS (1st stage), SR (2nd stage), SR (3rd stage), and SR (4th stage). The SR can be cultivated more than four times from one planting of parent rice.

6.2. Time and Height of Stem Cuttings

The SR cultivation ~~was~~ is better implemented in a land that ~~was~~ is not always inundated [37]. During two weeks before and after harvest, soil water content should be cultivated in field capacity. Initial shoots growth of SR ~~was~~ is better if the field capacity conditions than inundated. Rice ~~varieties'~~ varieties' ability to produce the number of shoots or tillers after cutting the stem of main rice ~~depended~~ depends on genetic and environmental characteristics, including soil water content availability. Shiraki et al. [38]~~,~~ stated that soil moisture conditions two weeks before and after the harvest ~~had a significant effect on~~significantly affects grain yield. Ratoon plants in dry soil moisture conditions can be increased yields by 69% than humid or flood conditions. According to Oda et al. [39], late irrigation ~~was~~ is recommended in ratoon rice management practices.

Cutting time of the stem at physiological maturity ~~was~~ is given the best ratoon yield [40]. Rice yields ~~were~~ are proportional to the number of ratoon tillers produced. The late stem cuttings ~~had~~ have the most effect on the ratoon tillers number [39]. The stem cutting shorter ~~caused~~ causes the ratoon growth to change longer at the vegetative stage of growth and ~~delayed~~ delays the maturity of the grain [41]. Cutting height significantly ~~influenced~~ influences plant height, the number of grains per panicle, and ~~the number of~~ filled grains. ~~Research by~~ Fitri et al. [7] showed that the optimal results for the number of productive tillers, the number of seeds per panicle, and rice productivity are obtained when the remaining stems ~~were~~ are cut at the height of 3-5 cm above the soil surface, and carried out at the age of 7-8 days after harvest (DAH).

The main ~~crop's~~ crop's first harvest ~~was~~ is done at 5 cm of cutting height [42]. Carbohydrates ~~were~~ are needed to maintain metabolic activity during the initial growth stages. The remaining stems provided the energy requirements for new ~~tillers'~~ tillers' growth after cutting, and then the tillers immediately ~~become~~ became autotrophic [8]. The highest yield of ratoon rice (Ciherang variety) ~~was~~ is achieved when cutting stems at harvest with a height of 3 cm above the soil surface with a grain yield of 3.54 tons ha^{-1} [43]. The effect of cutting height on rice yields depends on the photosynthetic conditions and the number of internodes remaining in the main stem as a place for ratoon shoots to appear [44].

There ~~were~~ are differences in the differentiation and dynamics of shoot growth at the stem nodes. The morphology of vegetative organs shows that hormones regulate shoot growth on the main stem nodes. There ~~were~~ are several proteins involved in brassinosteroid biosynthesis. Brassinosteroid signaling ~~can be played~~plays a role in the germination of axillary buds of ratoon rice [45]. The ability of rice crops to produce ratoon ~~was~~ is strongly influenced by the carbohydrate and phytohormone content left in the stem meristem tissue after harvest [46]. If the ~~stems'~~ stems' cutting ~~was~~ is done 2-3 cm from the soil surface, the new ~~shoots that germinate~~germin shoots ~~can~~ could be reproduced to form the next new rice tiller. The difference in the emergence of new shoots on the parent stem can be seen in Fig. **1**.

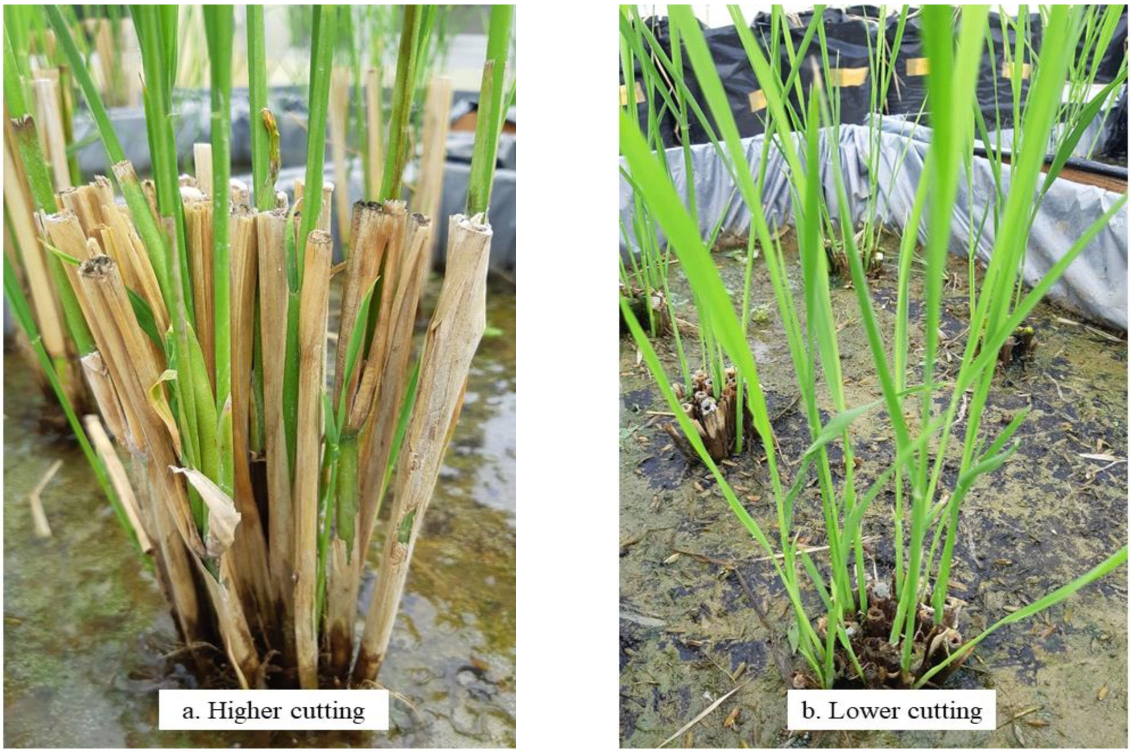

Fig. (1). The emergence of new shoots on the remaining stems with different cutting height in 14 DASC.~~.~~

In higher cutting (Fig. **1a**), new lateral shoots ~~emerged~~ emerge from the upper stem node. Stem cuttings taller ~~produced~~ produce more new shoots, and soon new leaf forms. Shoots ~~had~~ have short vegetative growth so that the leaves number ~~was~~ is small and the leaf area size ~~was~~ is narrow, and immediately move into the reproductive phase. In stem cutting lower (Fig. **1b**), new shoots grew from the basal stem. The s~~tem cuttings shorter caused new shoots to grow in the soil surface and immediately form new roots then shoots produce~~horter stem cuttings caused new shoots to grow in the soil surface and immediately form new roots, producing new tillers. Rice tillers ~~had~~ have a more extended vegetative growth phase and produce more and the leaf area broader. The leaf area number ~~affected~~ affects the photosynthesis process to produce carbohydrates.

The ratoon tillers ~~were~~ are related to the level of stem carbohydrates at harvest time [28]. Stem cuttings higher ~~caused~~ cause the plant to grow and flower quickly because the shoots take advantage of the remaining carbohydrate reserves in the stem of the parent plant. In contrast to stem cuttings shorter, ~~where~~ new shoots ~~were~~ are formed ~~that will be~~to produce~~d~~ new roots. Furthermore, the new shoots from the next new tillers so that the vegetative life ~~was~~ is longer. ~~The research results by~~ Mareza et al. [44] indicated that the ~~stem cuttings lower~~lower stem cuttings ~~caused~~ cause the tiller number clump^{-1} lower and more productive. The number and leaves area tiller^{-1} ~~was~~ is more and wider, but the leaf area clump^{-1} ~~was~~ is lower. Also, stem cutting ~~shorter resulted~~ results in flowering age and harvesting ~~is~~ being longer, tillers' dry weight higher, and the same seed carbohydrate content as the parent plant, but plant dry weight clump^{-1} ~~was~~ is lower.

6.3. Dose and Time of Fertilization

The regrowth of tillers depends on the carbohydrate reserves in the plant stems or roots remaining after pruning. The carbohydrates ~~were~~ are needed to maintain metabolic activity during the initial stages of regrowth. The energy ~~was~~ is required to supply new tillers immediately becomes autotrophic [47]. Furthermore, after the shoots grow, it takes a sufficient supply of nutrients from the environment to support normal growth like the previous parent rice. Nutrients in the soil during the harvest of the main crop greatly ~~affected~~ affect the performance of the shoots.

The growth and yields of SR ~~were~~ are primarily influenced by the balanced nutrients [8]. ~~Furthermore, b~~Better yields of ratooned crops were possible by increasing fertilization, mainly nitrogen [46]. ~~The S~~SR age ~~was~~ is shorter than the parent rice, so ~~there was a need to strengthen its vegetative growth using a balanced fertilization system~~a balanced fertilization system is needed to strengthen its vegetative growth.

Nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) ~~were~~ are the primary nutrients for increasing and sustaining SR productivity.

The urea fertilizer application can be increased the N element in the soil. The N availability can be caused plant leaves to look greener, the number of tillers was more, accelerate the growth of shoots, roots, photosynthesis, and stimulate rice ~~plants'~~ plants' growth. According to Ambarita et al. [48], the excessive N application will be inhibited the absorption of other elements so that growth and yield will be decreased and increased the amount of empty grain. ~~The research results by~~ Mamun et al. [49] showed that ~~the use of~~using an additional 25% nitrogen of the recommended dose for ratoon crops after harvesting the main crop can ~~be provide~~yield economic yields for hybrid rice.

Fertilizer application was done in 3 stages~~, t~~. The first fertilization was applied at 10 DAH (20% of urea dose), the second at 21 DAH (40% of urea dose), and the third at 35 DAH (40% of urea dose). The dose of 375 kg ha^{-1} urea application significantly affected the increase of the number of tillers (32.06 tillers $clump^{-1}$), the number of panicles (18.86 units $clump^{-1}$), and grain dry weight (0.63 kg m^{-2}) in SR cultivation of Ciherang variety [50]. The dose of 50 kg ha^{-1} urea and 50 kg ha^{-1} NPK Phonska fertilizer did not significantly affect rice production between the three zones of high, medium, and lowland on the Salibu system [7]. NPK Phonska was an inorganic fertilizer with the name NPK compound fertilizer consisting of several macronutrients, ~~namely~~ such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). The content of NPK Phonska 15-15-15 was N (15%), P_2O_5 (15%), K (15%), and S (10%). Rice farmers widely use~~d~~ this fertilizer because it can be increased yields and grain quality.

An increase in nitrogen dose within a certain range was followed by an increase in leaf area index, plant height, number of tillers, net photosynthesis rate, transpiration rate, and grain yield. In addition, increasing nitrogen dose on grain yield index and nitrogen contribution rate were parabolic [51]. The dosage of nitrogen fertilizer had a different effect on the number of tillers per clump, the percentage of filled grains per panicle, and the weight of 1000 grains [52]. The vegetative age of SR was shorter than the parent plant. Delay in fertilization can ~~be~~ lead to fewer tillers and decreased grain yields. Rice plants must be absorbed sufficient N, P, and K during the growth stage to obtain optimal growth characteristics and yields [53]. Fertilization of SR was carried out according to site-specific recommendations. According to Kristamtini et al. [4] dose of fertilizer application ~~was~~ is suitable with recommendations from paddy soil test equipment and was ~~gave~~ given in two times. The first fertilization was given as much as 40% of the recommended dose at 15-20 days after stem cuttings (DASC). The second fertilization was done as much as 60% of the recommended dose at 30-35 DASC. Suparwoto and Waluyo [54] stated that the first fertilization was done at ~~age of~~ 14 DASC by appl~~ication of~~ying 150 kg ha^{-1} urea fertilizer~~, and the second~~. The second was at ~~age of~~ 40 DASC with ~~the application of~~ 25 kg ha^{-1} SP-36 and 25 kg ha^{-1} KCl fertilizers.

Based on the results of previous studies, ~~it can be made a summary of the dose of fertilizer and time of fertilization in the cultivation of SR~~a summary of the dose of fertilizer and time of fertilization in the cultivation of SR can be made. For more details, it is shown in Table **4**.

Table 4. The dose and time of fertilization in salibu rice cultivation.

Dose of fertilizer	Time of fertilization	References
Recommendations from paddy soil test equipment	The first fertilization was applied as much as 40% of the recommended dose at 15-20 DASC, and the second was 60% of the recommended dose at 30-35 DASC.	Kristamtini et al. [4].
375 kg ha^{-1} urea	The first fertilization was applied at 10 DAH (20% of urea dose), the second at 21 DAH (40% of urea dose), and the third at 35 DAH (40% of urea dose).	Safrudin [50].
150 kg ha^{-1} urea, 150 kg ha^{-1} SP-36, and 25 kg ha^{-1} KCl	The first fertilization was applied at 14 DASC (150 kg ha^{-1} urea), the second was 40 DASC (150 kg ha^{-1} SP-36, and 25 kg ha^{-1} KCl).	Suparwoto and Waluyo [54].

Table 4 shows that the dose of fertilizer and the time of fertilization still look ~~very~~ varied. Therefore, it ~~was~~ is necessary to ~~do further research on~~research ~~the use of~~ the type and dose of fertilizer and the right time of application. Even though there ~~was~~ is no recommendation for site-specific fertilization, ~~the~~ SR cultivation ~~was~~ is still profitable compared to TS from the farming aspect.

The SR was more profitable than TS. The ~~cost savings of the production process can be made by the farmer~~farmers can make the cost savings of the production process in the second planting season. Production activities such as plowing, harrowing, nursery, seedlings removal, planting, and purchasing seeds were not carried out. According to Surdianto et al. [1], the comparison of costs among SR and TS is shown in Table 5.

Table 5. The comparison of costs among SR and TS.

No.	Cost description	Total (Rp. ha^{-1})		Cost difference (Rp. ha^{-1})
		SR	TS	
1.	Labor cost	(6,083,333)	(7,790,000)	1,706,667
	Nursery	-	330,000	
	Soil tillage	-	1,300,000	
	Planting	-	1,200,000	
	Stem cuttings	660,000	-	
	Maintenance (stitching, weeding, fertilization, and spraying)	3,440,000	2,720,000	
	Harvest and thresh	1,983,333	2,240,000	
2.	Cost of production facilities	(4,455,000)	(4,623,000)	168,000
	Seeds	-	480,000	
	Anorganik fertilizer	1,145,000	1,505,00	
	Manure fertilizer	1,680,000	900,000	
	Pesticide	1,630,000	1,738,00	
1 + 2	Total	10,338,333	11,483,000	1,874,667

Remarks: - = No activity, SR = Salibu rice, and TS = Transplanting system.

Source: Surdianto et al. [1].

Table 5 shows that the cost difference between the SR and TS ~~was~~ is ~~as much as~~ Rp. 1,874,667 ha^{-1} for each growing season. It means~~, the SR cultivation system can be increased farmers' income along with~~ the SR cultivation system can increase farmers' income and production costs that can be eliminated.

CONCLUSION AND RECOMMENDATION

~~Based on the review literature above showed that the progress of~~The reviewed literature above showed that the development of SR cultivation in Indonesia was ~~very~~ slow, but it can be improved again. Farmers need to apply the agronomic factors that affect the success of SR cultivation. The soil water availability for one year will be determined the number of stages of SR cultivation. ~~During t~~Two weeks before and after harvesting ~~of~~ parent rice, soil water content should be cultivated in field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 DAH were the right method for SR cultivation. ~~The use of f~~Fertilizer dose was carried out according to site-specific recommendations. The first fertilization was given as much as 40% at 14-21 DASC and the second as much as 60% at 30-40 DASC. The soil water availabity, time and height of the stem cuttings, and dose and time of fertilization ~~affect~~ affected SR cultivation. Three agronomic factors need to be applied by farmers in SR cultivation.

LIST OF ABBREVIATIONS

DAH	=	Days After Harvest
DAP	=	Days After Planting
DASC	=	Days After Stem Cuttings
N, P, K, S		Nitrogen, Phosphorus, Potassium (K), and Sulfur
SR	=	Salibu Rice
TS	=	Transplanting System

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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3. Manuscript without the Highlights

The Role of Agronomic Factors in Salibu Rice Cultivation

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Abstract:

Background:

Salibu rice cultivation is one of the technologies that have been developed in Indonesia but has not continued. This technology has great potential to increase land productivity. The unsustainability of the salibu rice cultivation is due to the yield lower than the parent rice. Not many famers are know of the agronomic factors that can increase the growth and yield of salibu rice.

Objective:

This review article aims to know the role of agronomic factors in salibu rice cultivation.

Results:

The review article showed that agronomic factors had a major role in salibu rice cultivation. Among the factors had a major role follows. The soil water availability for one year would be determined by the number of stages of SR cultivation. Two weeks before and after harvesting parent rice, soil water content should have been cultivated in field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 days after harvest were the right SR cultivation methods. The use of fertilizer dose was carried out according to site-specific recommendations. The first fertilization was given as much as 40% at 14-21 days after stem cuttings, and the second was as much as 60% at 30-40 days after stem cuttings in salibu rice cultivation.

Conclusion:

Among the agronomic factors affecting salibu rice cultivation are soil water availability, the time and height of stem cuttings, the dose and time of fertilization. Three agronomic factors need to be considered and applied by farmers to get the maximum growth and yield of salibu rice.

Keywords: Cultivation, Fertilizer, Parent rice, Superior variety, Salibu rice, Soil water, Stem cuttings.

Running title: Agronomic factors in salibu rice cultivation

7. INTRODUCTION

Various innovations are continuously made to increase national food self-sufficiency and farmers' income. One of the innovations is using salibu rice (SR) cultivation technology. Salibu is an abbreviation from '*salin ibu*' (change parent in English). However, SR cultivation has been developed in various Indonesian regions but has not received a good response from farmers. As a result, SR cultivation is stagnant in Indonesia. Indeed, SR production is considered lower than the transplanting system (TS). The low production is because farmers do not know the role of agronomic factors affecting the growth and yield of SR.

Rice is a food crop that has been cultivated from generation to generation by Indonesian farming communities. This technology is more efficient in cost and labor than the TS because it does not involve tillage, seeding, and planting. Not many rice farmers understand the benefits of using this technology. The SR cultivation can increase land productivity and farmer income, increase cropping intensity, efficient use of resources, and lower production costs. According to Surdianto et al. [1], the SR was effective enough to be developed so that farmers had the opportunity to adopt this technology to increase the cropping index (harvest index) and rice production.

The SR cultivation provided hope as a climate-smart technology and resource. The SR provided an opportunity to increase harvest intensity per year because the growth duration was shorter than the parent rice. Besides, it can be cultivated with less than 50% labor, 60% water availability lower, and production costs lower than the parent rice [2]. The effectiveness of water use in SR cultivation was also higher [3]. This technology was feasible to be developed because it had a benefit-cost ratio > 1. The SR cultivation had a crop maturity period shorter (decreased by 45.66%), so it was a technological breakthrough to anticipate climate change (drought) [4].

According to Erdiman et al. [5], the harvest age of the main crop could be done ten days early than TS to be prepared as parent SR. Then, the activity differences others in SR and TS are presented in Table **1**.

Table 1. The activity differences in SR and TS cultivation.

Activity	Cultivation system	
	SR	**TS**
Land preparation	Stem cuttings after TS harvest	Cleaning the leftover straw
Soil tillage	-	Plowing and harrowing

Seeding	-	Yes
Planting	-	Yes
Fertilization	Following recommendations of site-specific and increase in N (25-50%)	Following recommendations of site-specific
Thinning and embroidery	20-25 days after stem cuttings (DASC) of parent rice	25-30 days after planting (DAP)
Maintenance	Standard of plant pests	Standard of plant pests
Harvest age	20% earlier than the age of TS harvest	Following harvest age

Remarks: - = No activity, SR = Salibu rice, and TS = Transplanting system.

Source: Erdiman et al. [5].

Table **1** shows that the difference in activities between SR and TS have no soil tillage, seeding, and planting, so SR is more efficient in using labor. N fertilizer should be increased to stimulate vegetative growth because the SR lifespan is shorter. The first and second fertilization is done earlier than the TS. The harvest age of SR is 20% faster than TS.

The SR cultivation has not been much in demand by the farming community because of its low production. The slow development of this technology was due to the lack of information on research results so that farmers did not dare to speculate about trying SR cultivation. A study to know the agronomic factors affecting the growth and yield of SR needs to be done. Thus, SR cultivation could be developed again to maintain food in Indonesia. A literature review is necessary to provide complete information about the right of SR cultivation. This review article aims to know the role of agronomic factors in SR cultivation.

8. SALIBU RICE

The first SR was developed in West Sumatera (Indonesia). SR is a form of local wisdom-based technology that can solve the increasing need for food in Indonesia. Its harvest life is shorter than the parent rice, so it is possible to harvest four times in one year. Appropriate technology for rice harvesting is needed to increase time efficiency (not much time was lost). According to Hasan et al. [6], the application of appropriate technology for rice harvesting in developing countries is urgently needed to increase cropping intensity, crop productivity, and less time, effort, and input costs.

SR is a modification of rice cultivation from ratoon rice. The stem cutting of the parent rice shorter or closer to the soil surface are more suitable for SR cultivation technology [7]. SR grows from the remaining stems that are cut after harvest. New shoots will emerge from the remaining stems near the soil surface and form new roots. Initial growth and the strength of tiller formation depend on the carbohydrate reserves of the stem and root of the parent rice. Furthermore, it is supported by new leaves so that the supply of carbohydrates is no longer dependent on the previous parent plant. The shoots will form new tillers again like TS.

The growth and yields of SR are influenced largely by rice variety [8]. The superior varieties of seed are more important and beneficial for rice productivity [9]. The selection of parent rice seeds prioritized superior varieties with high production and short life. Short-lived types can increase the cropping index. Superior varieties with high production, resistance to pests and diseases, and tolerance to abiotic problems can be increased rice yields. According to Bui *et al.* [10], tolerant varieties have higher survival rates and less shoot elongation but longer root elongation during immersion than sensitive varieties.

According to Sastro et al. [11], the several inbred and hybrid rice have high production and harvested lives shorter in Indonesia, and the superior rice varieties are shown in Table **2**.

Table 2. List of superior variety from inbred and hybrid in Indonesia.

Superior varieties	**Harvest age (days)**	**Average yields (ton ha^{-1})**	**Potential yield (ton ha^{-1})**
Inbred rice:			
Inpari 11	105	6.5	8.8
Inpari 13	99	6.6	8.0
Inpari 18	102	6.7	9.5
Inpari 19	104	6.7	9.5
Inpari Sidenuk	103	6.9	9.1
Padjajaran Agritan	105	7.8	11.0
Cakrabuana Agritan	104	7.5	10.2
Hybrid rice:			
Hipa 10	114	8.1	9.4
Hipa 11	114	8.4	10.6
Hipa 12 SBU	105	7.7	10.5

Hipa 13	105	7.7	10.5
Hipa 14	112	8.4	12.1
Hipa 18	113	7.8	10.3
Hipa 19	111	7.8	10.1

Source: Sastro et al. [11].

Table **2** shows that hybrid rice has production higher than inbred rice. The hybrids in Indonesia have potential high production and shorter harvest age. The hybrid rice of Hipa 10, Hipa 11, and Hipa 14 can be used as the parent rice. These superior varieties, as parent rice, are expected to reduce high-producing genetic traits. Lardi *et al*. [8] stated that under natural conditions, plant growth is largely determined by the plants' genetic factors, especially the condition of growth regulators (hormones). According to Liu *et al*. [12], SR growth is influenced by the growth of parent rice, so it can be evaluated by determining parent rice-growing conditions.

The yield of grain in SR plants is a complement to the parent rice [13]. The high yield of hybrid rice is due to the increased harvest index. The hybrid is yielded significantly higher productivity than those cultivated in the dry season, but the difference is not significant in the wet season. Hybrids produce spikelet panicle^{-1} and 1000 grain dry weight higher than inbred rice [14]. The ratoon yield of the hybrids is better than inbred. The average result was 75.2% of the parent rice [15]. Short-lived varieties are more profitable [16]. Ratoon yields are higher using hybrid than inbred rice [17]. Utilization of the hybrid ratoon rice in androgenetic conditions will be saved cultivation time and costs [18].

Rice production is influenced by some factors, such as varieties, management, and environments. Among the environmental factors are agronomic traits and climate [19]. Land-use efficiency forms must be developed continuously [20]. The land is a key factor in production agriculture [21]. Rice as a perennial crop produces a stable and sustainable grain yield over successive seasons across years [22]. Hybrid rice had productivity and profitability higher [23]. Besides, agricultural technology innovation is an important factor in supporting increased rice production [24]. The efforts of SR cultivation are made to increase land productivity to meet food needs through SR cultivation. Rice crops can be cultivated many times a year by SR cultivation to increase land productivity. Agronomic factors have a big role in increasing SR production.

9. AGRONOMIC FACTORS

9.1. Availability of Soil Water

SR allows rice harvests of 3.5–4 times year^{-1} with yields equivalent to the parent rice [7]. The increasing number in the harvest index depends on the water availability conditions. According to Negalur et al. [2], SR has a short growing duration, suitable in rainfed areas with residual soil moisture. Rainfed rice fields can be planted once or twice in harvests, making planning difficult depending on the unpredictable rainwater. Harvesting can be done 3-4 times year^{-1} on semi-technical rice fields and technical irrigation. The cropping system patterns of TS (1st stage), SR (2nd stage), and SR (3rd stage) are more profitable than TS (1st stage) and TS (2nd stage) in one year.

The selection of rice varieties is better determined by water conditions in the field [25]. Increasing land productivity is a determining factor for rainfed rice farming [26]. Rice breeders regard ratooning as an important practice for sustainable rice production in tropical agricultural systems to maximize profits [27]. Rainfed land has important benefits in increasing food production. TS is better than the seed-direct system. There is a time to take advantage of residual soil moisture [16]. Rice cultivation in rainfed lowland can increase from one to two harvests using the TS (1st stage) and SR (2nd stage) in a year.

The soil moisture content influences the main crop harvest [28]. The inundation height of 5 cm from the soil surface results in plants taller and more tillers than the saturated condition treatment with a 0.5 cm water layer [29]. Saturated conditions up to 1 cm in height can be applied in rice cultivation by farmers and do not affect rice production and soil characteristics [30]. Ratoon rice yields show that inundation (full flooding) gives the highest yield than inundation intervals of 2, 4, and 6 days [31].

In contrast to Elkheir et al. [32], each soil type is essential to conserve water, and yields show better rice production under aerobic conditions. According to Bleoussi et al. [33], the protein content of each rice variety increases with increasing drought- intensity. The groundwater deficit has significant implications for grain quality. Momolu [34] stated that grain yields for all rice cultivars decrease with the formation of tillers and theses due to the extended stress period.

The rice field ecosystem is divided into lowlands, highlands, and waters. Rice ratooning is more suitable for lowland rice fields [35]. The SR cultivation can be done on rainfed land, although it can be done in two stages, TS (1st stage) and SR (2nd stage), due to the limited availability of soil water. Barnaby et al. [36] stated that rice plants have a variety of physiological and metabolic strategies in producing tolerance to water stress. It is necessary for rice varieties selection that is adaptable to deficit irrigation production systems or less water. The model of SR cultivation pattern is presented in Table **3**.

Table 3. The model of SR cultivation in rice fields.

Rice fields types	**Generation of the rice plant**			
	TS (1st generation)	**SR (2nd generation)**	**SR (3rd generation)**	**SR (4th generation)**
Rainfed land	ϴ	√	-	-
Semi-technical irrigated	ϴ	√	√	-
Technical irrigated	ϴ	√	√	√

Remarks: TS = Transplanting system, SR = Salibu rice, ϴ = TS cultivation, √ = SR cultivation, and - = No cultivation.

Table **3** shows that soil water availability for one year will determine the number of SR cultivation stages. In semi-technical irrigated land, it can be increased to 3 harvests year^{-1} with the patterns, TS (1st stage), SR (2nd stage), and SR (3rd stage). In comparison, on technical irrigated land, it can be increased to 4 rice harvests a year with the patterns, the TS (1st stage), SR (2nd stage), SR (3rd stage), and SR (4th stage). The SR can be cultivated more than four times from one planting of parent rice.

9.2. Time and Height of Stem Cuttings

The SR cultivation is better implemented in a land that is not always inundated [37]. During two weeks before and after harvest, soil water content should be cultivated in field capacity. Initial shoots growth of SR is better if the field capacity conditions than inundated. Rice varieties' ability to produce the number of shoots or tillers after cutting the stem of main rice depends on genetic and environmental characteristics, including soil water content availability. Shiraki et al. [38] stated that soil moisture conditions two weeks before and after the harvest significantly affects grain yield. Ratoon plants in dry soil moisture conditions can be increased yields by 69% than humid or flood conditions. According to Oda et al. [39], late irrigation is recommended in ratoon rice management practices.

Cutting time of the stem at physiological maturity is given the best ratoon yield [40]. Rice yields are proportional to the number of ratoon tillers produced. The late stem cuttings have the most effect on the ratoon tillers number [39]. The stem cutting shorter causes the ratoon growth to change longer at the vegetative stage of growth and delays the maturity of the grain [41]. Cutting height significantly influences plant height, the number of grains per panicle, and filled grains. Fitri et al. [7] showed that the optimal results for the number of productive tillers, the number of seeds per panicle, and rice productivity are obtained when the remaining stems are cut at the height of 3-5 cm above the soil surface, and carried out at the age of 7-8 days after harvest (DAH).

The main crop's first harvest is done at 5 cm of cutting height [42]. Carbohydrates are needed to maintain metabolic activity during the initial growth stages. The remaining stems provided the energy requirements for new tillers' growth after cutting, and then the tillers immediately became autotrophic [8]. The highest yield of ratoon rice (Ciherang variety) is achieved when cutting stems at harvest with a height of 3 cm above the soil surface with a grain yield of 3.54 tons ha^{-1} [43]. The effect of cutting height on rice yields depends on the photosynthetic conditions and the number of internodes remaining in the main stem as a place for ratoon shoots to appear [44].

There are differences in the differentiation and dynamics of shoot growth at the stem nodes. The morphology of vegetative organs shows that hormones regulate shoot growth on the main stem nodes. There are several proteins involved in brassinosteroid biosynthesis. Brassinosteroid signaling plays a role in the germination of axillary buds of ratoon rice [45]. The ability of rice crops to produce ratoon is strongly influenced by the carbohydrate and phytohormone content left in the stem meristem tissue after harvest [46]. If the stems' cutting is done 2-3 cm from the soil surface, the new germin shoots could be reproduced to form the next new rice tiller. The difference in the emergence of new shoots on the parent stem can be seen in Fig. **1**.

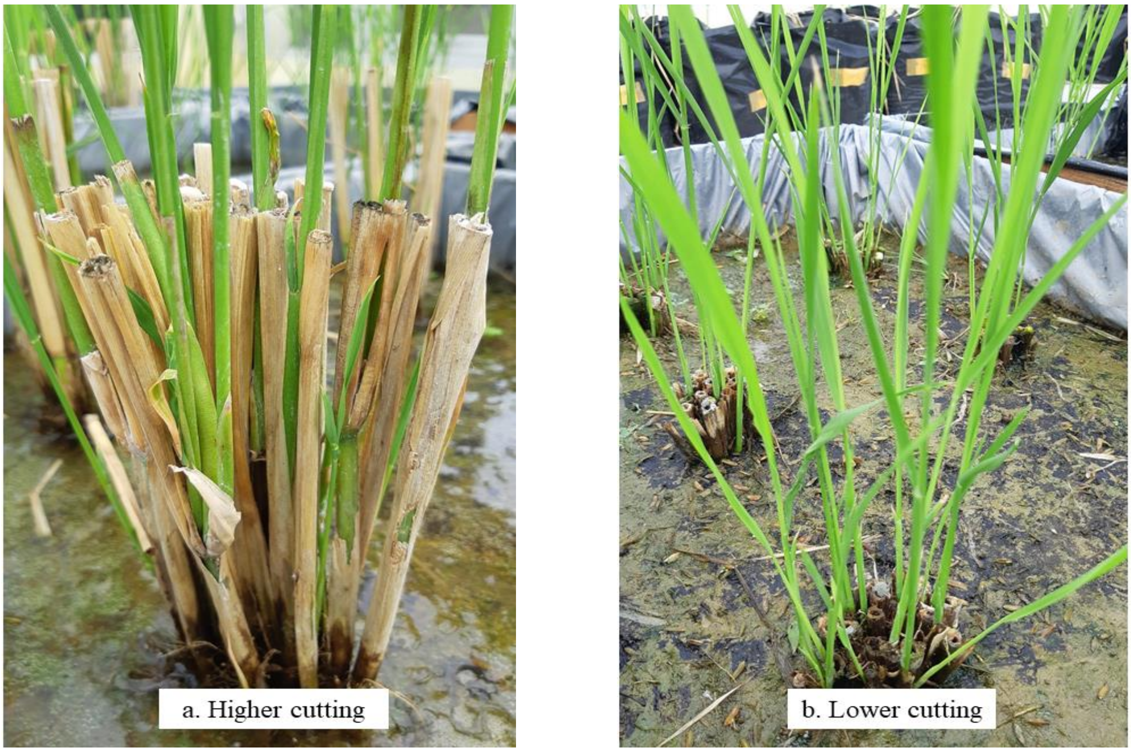

Fig. (1). The emergence of new shoots on the remaining stems with different cutting height in 14 DASC.

In higher cutting (Fig. **1a**), new lateral shoots emerge from the upper stem node. Stem cuttings taller produce more new shoots, and soon new leaf forms. Shoots have short vegetative growth so that the leaves number is small and the leaf area size is narrow, and immediately move into the reproductive phase. In stem cutting lower (Fig. **1b**), new shoots grew from the basal stem. The shorter stem cuttings caused new shoots to grow in the soil surface and immediately form new roots, producing new tillers. Rice tillers have a more extended vegetative growth phase and produce more and the leaf area broader. The leaf area number affects the photosynthesis process to produce carbohydrates.

The ratoon tillers are related to the level of stem carbohydrates at harvest time [28]. Stem cuttings higher cause the plant to grow and flower quickly because the shoots take advantage of the remaining carbohydrate reserves in the stem of the parent plant. In contrast to stem cuttings shorter, new shoots are formed to produce new roots. Furthermore, the new shoots from the next new tillers so that the vegetative life is longer. Mareza et al. [44] indicated that the lower stem cuttings cause the tiller number clump^{-1} lower and more productive. The number and leaves area tiller^{-1} is more and wider, but the leaf area clump^{-1} is lower. Also, stem cutting results in flowering age and harvesting being longer, tillers' dry weight higher, and the same seed carbohydrate content as the parent plant, but plant dry weight clump^{-1} is lower.

9.3. Dose and Time of Fertilization

The regrowth of tillers depends on the carbohydrate reserves in the plant stems or roots remaining after pruning. The carbohydrates are needed to maintain metabolic activity during the initial stages of regrowth. The energy is required to supply new tillers immediately becomes autotrophic [47]. Furthermore, after the shoots grow, it takes a sufficient supply of nutrients from the environment to support normal growth like the previous parent rice. Nutrients in the soil during the harvest of the main crop greatly affect the performance of the shoots.

The growth and yields of SR are primarily influenced by the balanced nutrients [8]. Better yields of ratooned crops were possible by increasing fertilization, mainly nitrogen [46]. SR age is shorter than the parent rice, so a balanced fertilization system is needed to strengthen its vegetative growth. Nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) are the primary nutrients for increasing and sustaining SR productivity.

The urea fertilizer application can be increased the N element in the soil. The N availability can be caused plant leaves to look greener, the number of tillers was more, accelerate the growth of shoots, roots, photosynthesis, and stimulate rice plants' growth. According to Ambarita et al. [48], the excessive N application will be inhibited the absorption of other elements so that growth and yield will be decreased and increased the amount of empty grain. Mamun et al. [49] showed that using an additional 25% nitrogen of the recommended dose for ratoon crops after harvesting the main crop can yield economic yields for hybrid rice.

Fertilizer application was done in 3 stages. The first fertilization was applied at 10 DAH (20% of urea dose), the second at 21 DAH (40% of urea dose), and the third at 35 DAH (40% of urea dose). The dose of 375 kg ha^{-1} urea application significantly affected the increase of the number of tillers (32.06 tillers $clump^{-1}$), the number of panicles (18.86 units $clump^{-1}$), and grain dry weight (0.63 kg m^{-2}) in SR cultivation of Ciherang variety [50]. The dose of 50 kg ha^{-1} urea and 50 kg ha^{-1} NPK Phonska fertilizer did not significantly affect rice production between the three zones of high, medium, and lowland on the Salibu system [7]. NPK Phonska was an inorganic fertilizer with the name NPK compound fertilizer consisting of several macronutrients, such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). The content of NPK Phonska 15-15-15 was N (15%), P_2O_5 (15%), K (15%), and S (10%). Rice farmers widely use this fertilizer because it can be increased yields and grain quality.

An increase in nitrogen dose within a certain range was followed by an increase in leaf area index, plant height, number of tillers, net photosynthesis rate, transpiration rate, and grain yield. In addition, increasing nitrogen dose on grain yield index and nitrogen contribution rate were parabolic [51]. The dosage of nitrogen fertilizer had a different effect on the number of tillers per clump, the percentage of filled grains per panicle, and the weight of 1000 grains [52]. The vegetative age of SR was shorter than the parent plant. Delay in fertilization can lead to fewer tillers and decreased grain yields. Rice plants must be absorbed sufficient N, P, and K during the growth stage to obtain optimal growth characteristics and yields [53]. Fertilization of SR was carried out according to site-specific recommendations. According to Kristamtini et al. [4] dose of fertilizer application is suitable with recommendations from paddy soil test equipment and was given in two times. The first fertilization was given as much as 40% of the recommended dose at 15-20 days after stem cuttings (DASC). The second fertilization was done as much as 60% of the recommended dose at 30-35 DASC. Suparwoto and Waluyo [54] stated that the first fertilization was done at 14 DASC by applying 150 kg ha^{-1} urea fertilizer. The second was at 40 DASC with 25 kg ha^{-1} SP-36 and 25 kg ha^{-1} KCl fertilizers.

Based on the results of previous studies, a summary of the dose of fertilizer and time of fertilization in the cultivation of SR can be made. For more details, it is shown in Table **4**.

Table 4. The dose and time of fertilization in salibu rice cultivation.

Dose of fertilizer	Time of fertilization	References
Recommendations from paddy soil test equipment	The first fertilization was applied as much as 40% of the recommended dose at 15-20 DASC, and the second was 60% of the recommended dose at 30-35 DASC.	Kristamtini et al. [4].
375 kg ha^{-1} urea	The first fertilization was applied at 10 DAH (20% of urea dose), the second at 21 DAH (40% of urea dose), and the third at 35 DAH (40% of urea dose).	Safrudin [50].
150 kg ha^{-1} urea, 150 kg ha^{-1} SP-36, and 25 kg ha^{-1} KCl	The first fertilization was applied at 14 DASC (150 kg ha^{-1} urea), the second was 40 DASC (150 kg ha^{-1} SP-36, and 25 kg ha^{-1} KCl).	Suparwoto and Waluyo [54].

Table 4 shows that the dose of fertilizer and the time of fertilization still look varied. Therefore, it is necessary to research the type and dose of fertilizer and the right time of application. Even though there is no recommendation for site-specific fertilization, SR cultivation is still profitable compared to TS from the farming aspect.

The SR was more profitable than TS. The farmers can make the cost savings of the production process in the second planting season. Production activities such as plowing, harrowing, nursery, seedlings removal, planting, and purchasing seeds were not carried out. According to Surdianto et al. [1], the comparison of costs among SR and TS is shown in Table 5.

Table 5. The comparison of costs among SR and TS.

No.	Cost description	Total (Rp. ha^{-1})		Cost difference (Rp. ha^{-1})
		SR	TS	
1.	Labor cost	(6,083,333)	(7,790,000)	1,706,667

	Nursery	-	330,000	
	Soil tillage	-	1,300,000	
	Planting	-	1,200,000	
	Stem cuttings	660,000	-	
	Maintenance (stitching, weeding, fertilization, and spraying)	3,440,000	2,720,000	
	Harvest and thresh	1,983,333	2,240,000	
2.	Cost of production facilities	(4,455,000)	(4,623,000)	168,000
	Seeds	-	480,000	
	Anorganik fertilizer	1,145,000	1,505,00	
	Manure fertilizer	1,680,000	900,000	
	Pesticide	1,630,000	1,738,00	
1 + 2	Total	10,338,333	11,483,000	1,874,667

Remarks: Rp. = Rupiah (Indonesia), - = No activity, SR = Salibu rice, and TS = Transplanting system.

Source: Surdianto et al. [1].

Table 5 shows that the cost difference between the SR and TS is Rp. 1,874,667 ha^{-1} for each growing season. It means the SR cultivation system can increase farmers' income and production costs that can be eliminated.

CONCLUSION AND RECOMMENDATION

The reviewed literature above showed that the development of SR cultivation in Indonesia was slow, but it can be improved again. Farmers need to apply the agronomic factors that affect the success of SR cultivation. The soil water availability for one year will be determined the number of stages of SR cultivation. Two weeks before and after harvesting parent rice, soil water content should be cultivated in field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 DAH were the right method for SR cultivation. Fertilizer dose was carried out according to site-specific recommendations. The first fertilization was given as much as 40% at 14-21 DASC and the second as much as 60% at 30-40 DASC. The soil water availabity, time and height of the stem cuttings, and dose and time of fertilization affected SR cultivation. Three agronomic factors need to be applied by farmers in SR cultivation.

LIST OF ABBREVIATIONS

DAH	=	Days After Harvest
DAP	=	Days After Planting
DASC	=	Days After Stem Cuttings
N, P, K, S		Nitrogen, Phosphorus, Potassium (K), and Sulfur
SR	=	Salibu Rice
TS	=	Transplanting System

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No humans or animals were used in this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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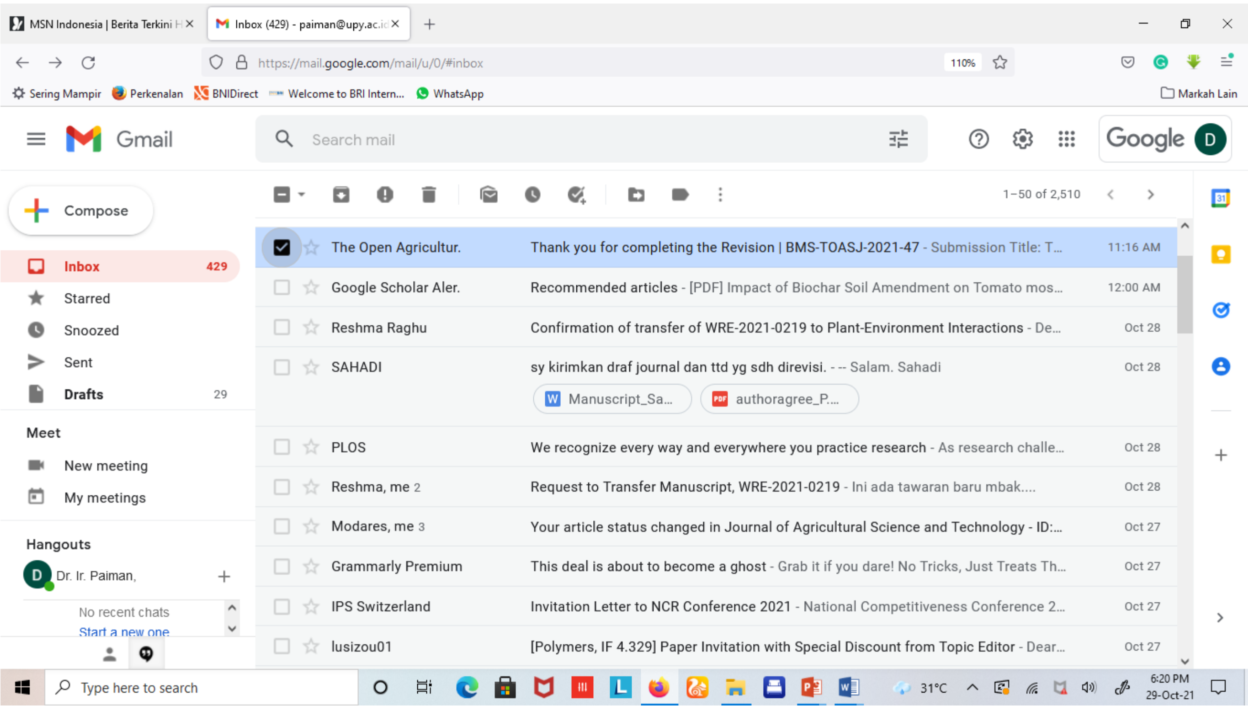

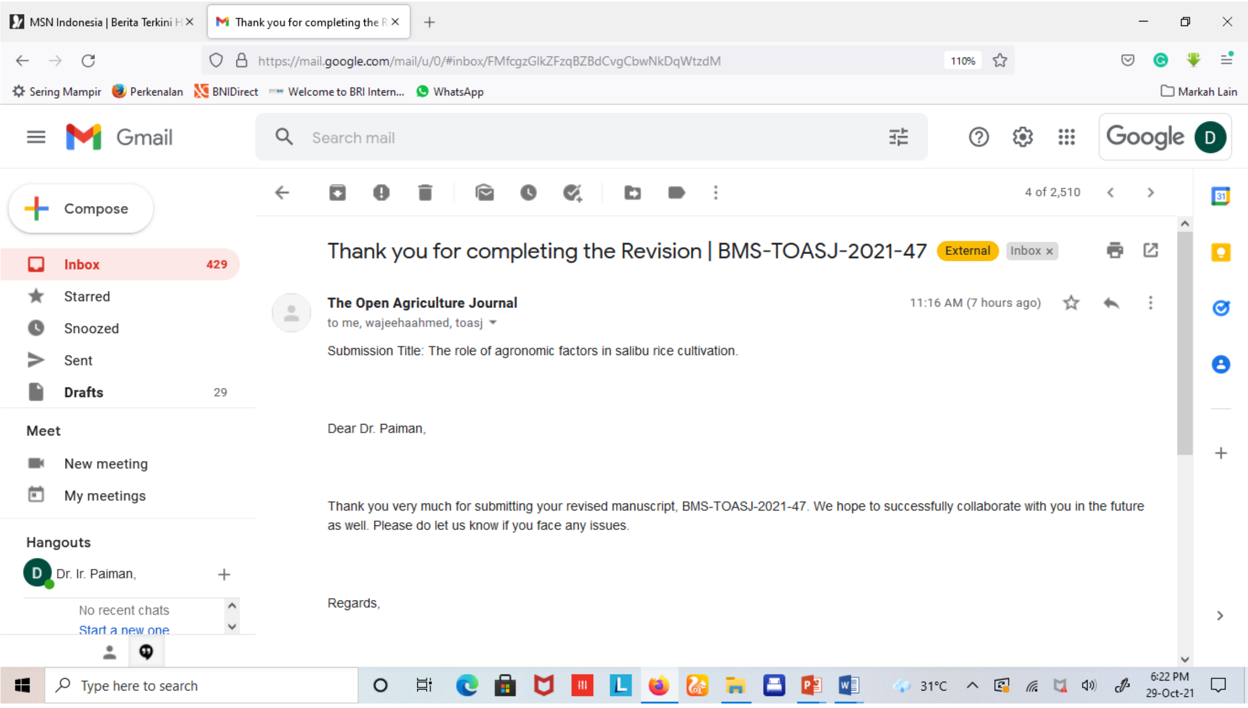

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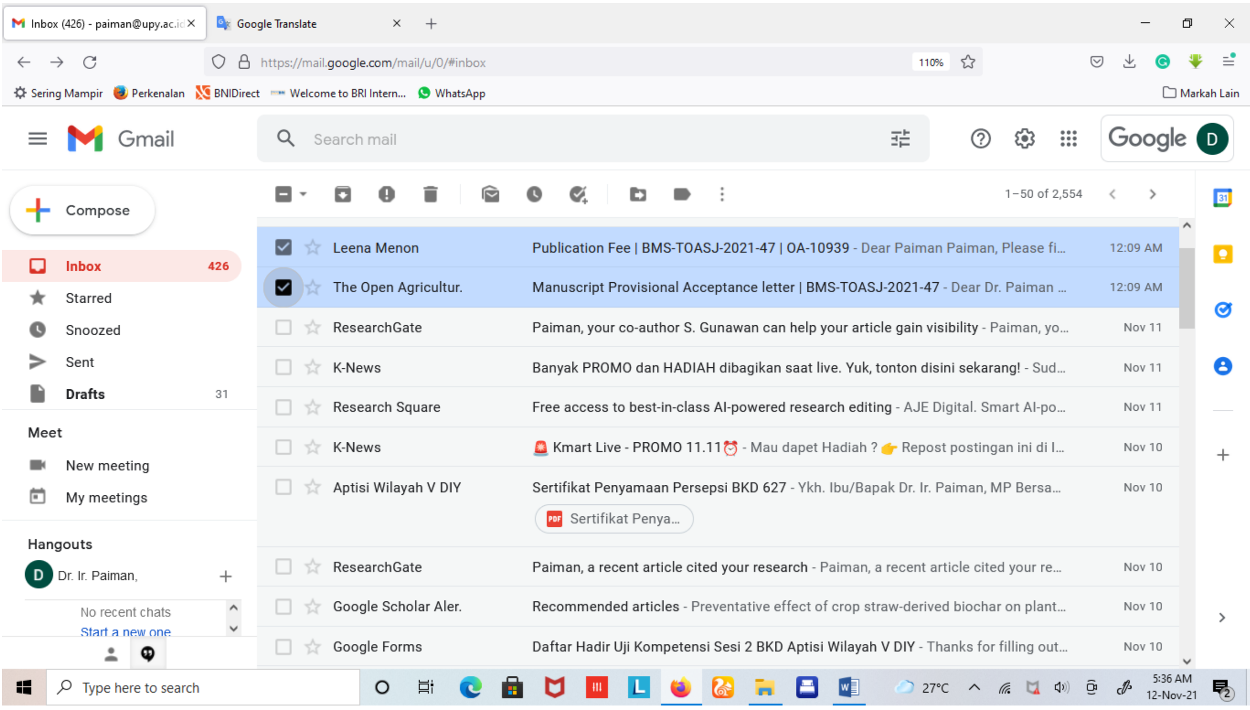

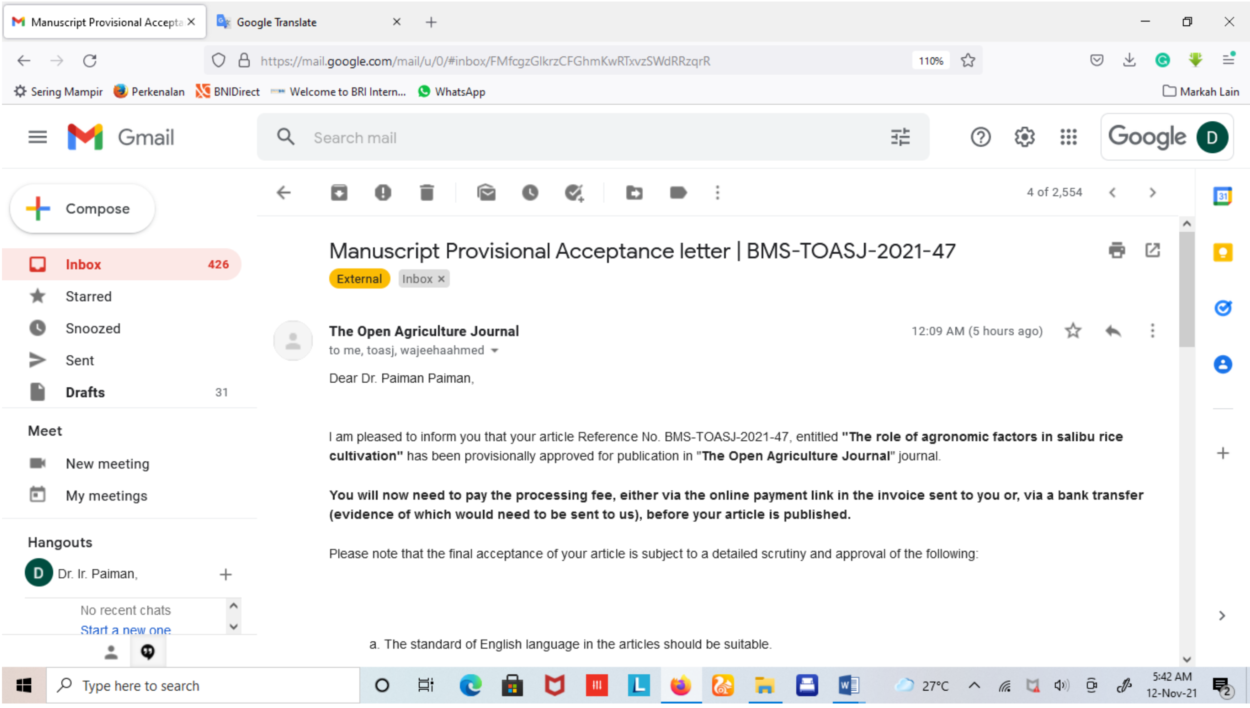

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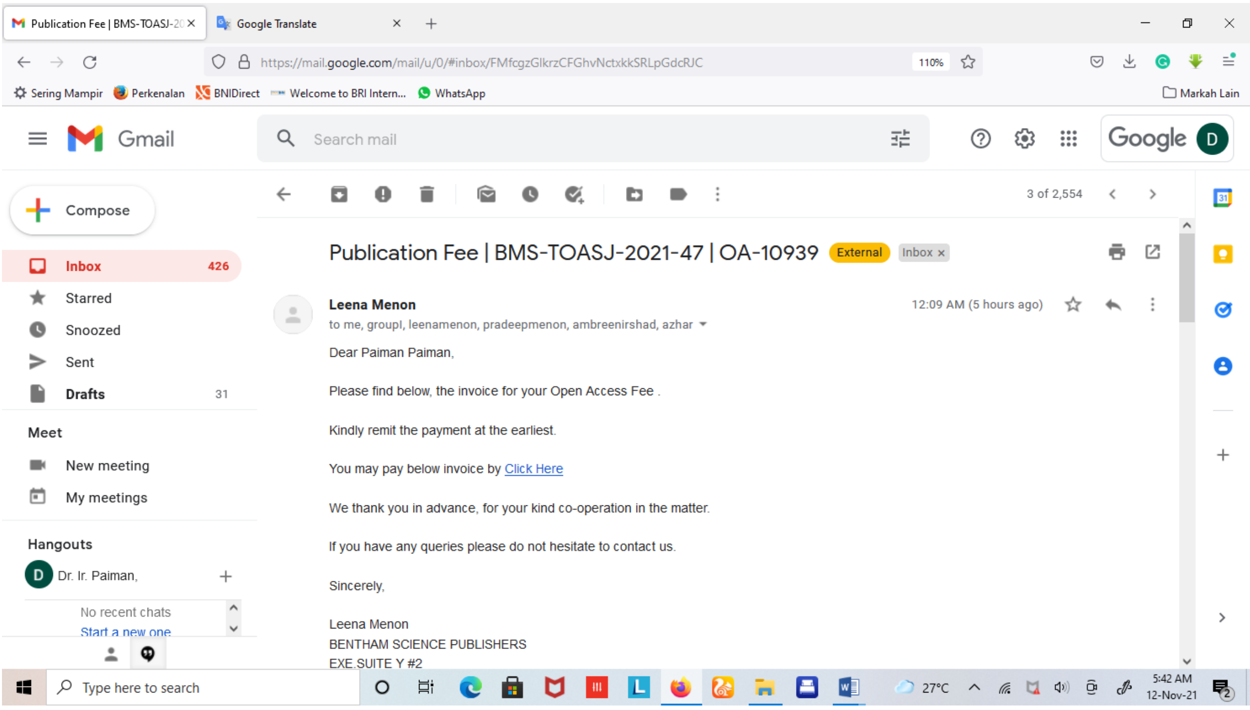

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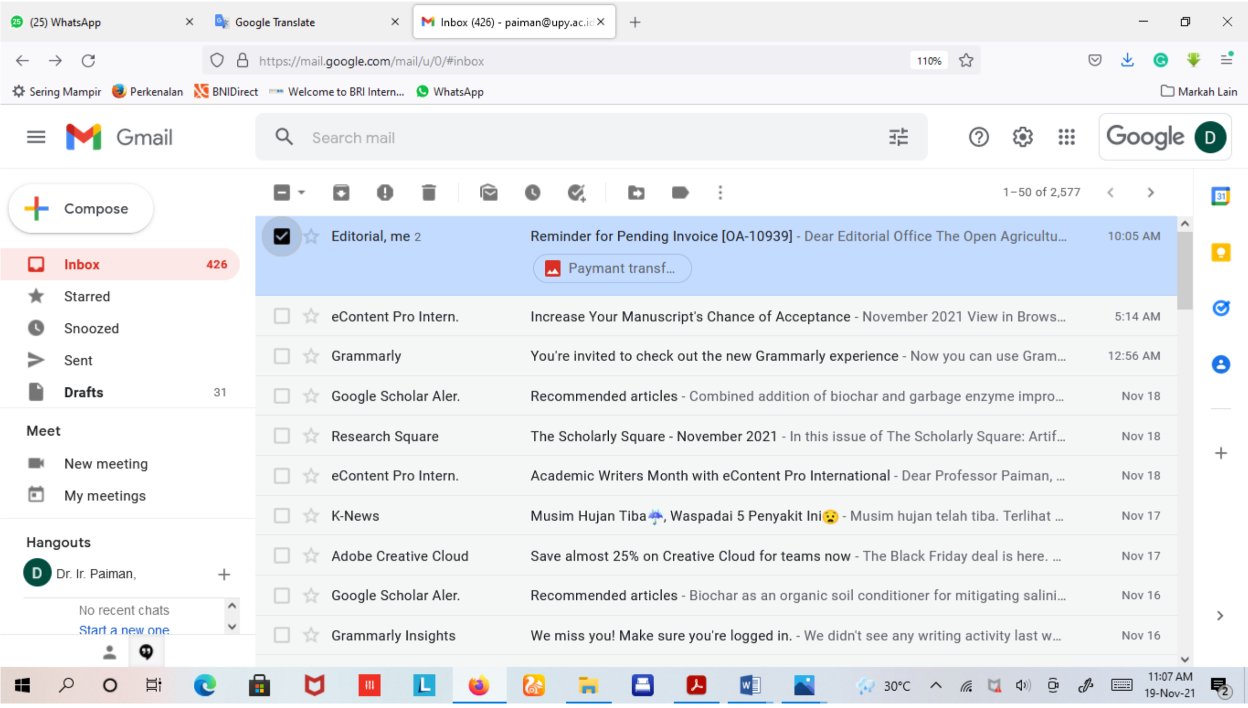

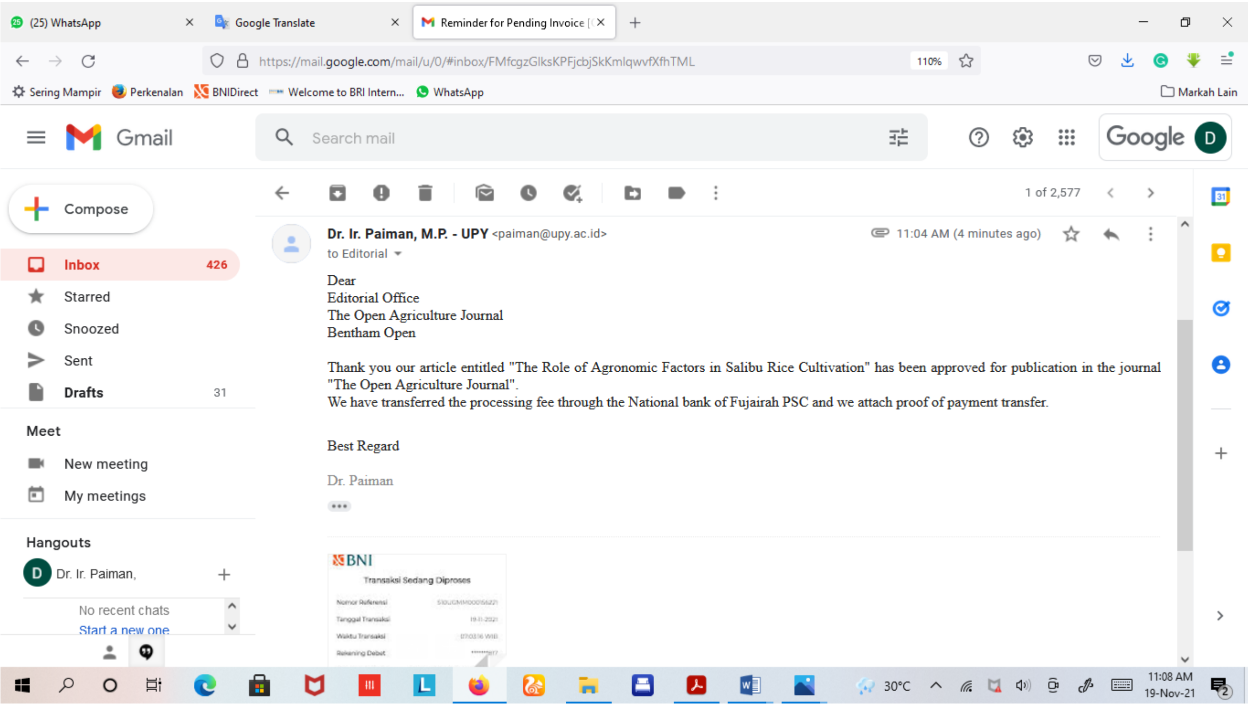

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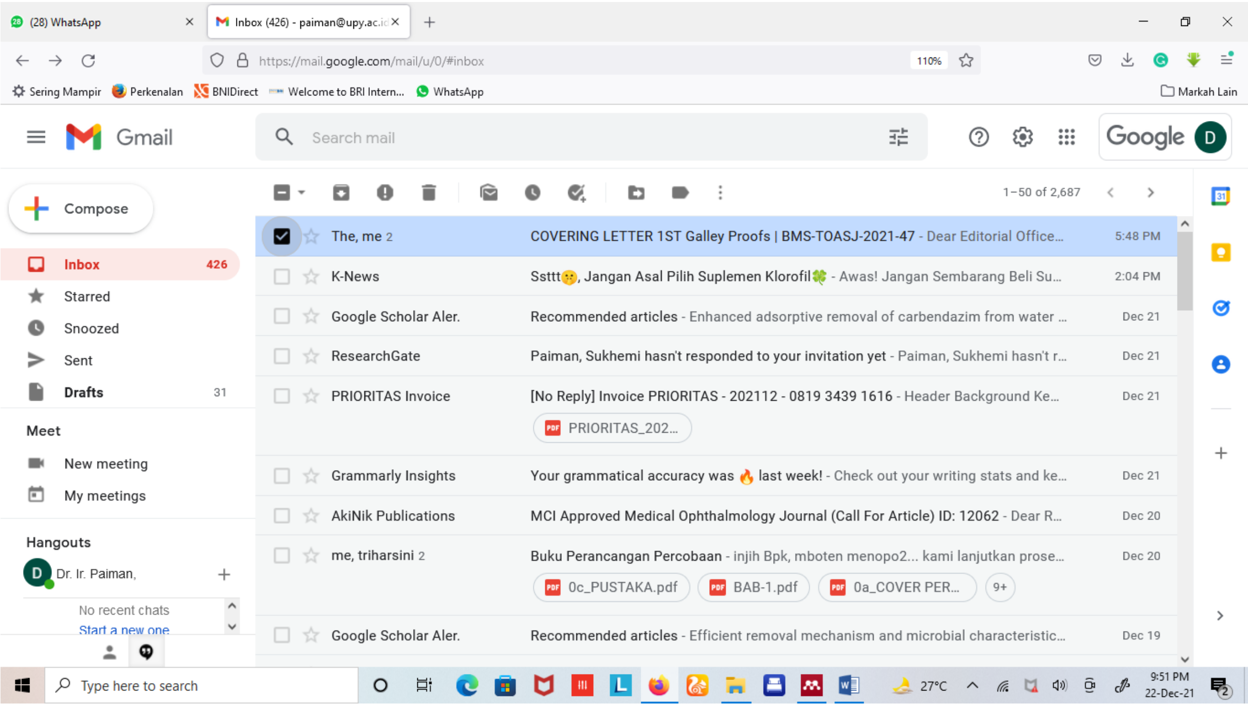

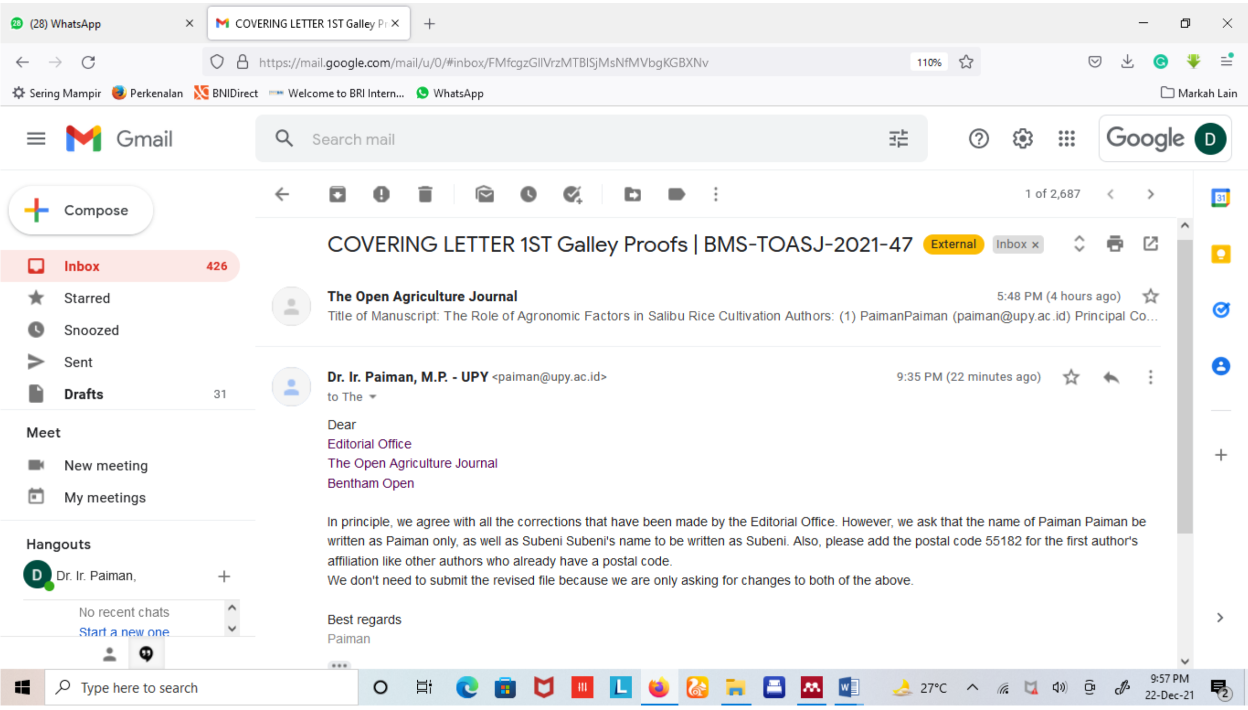

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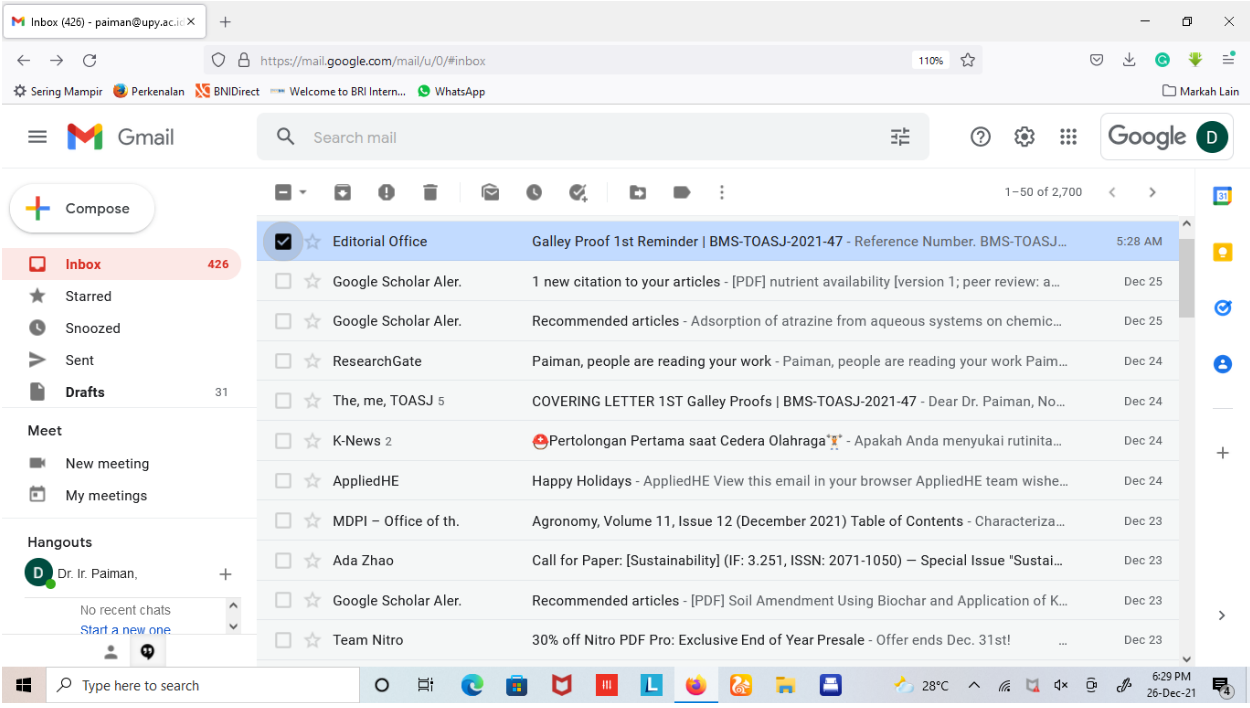

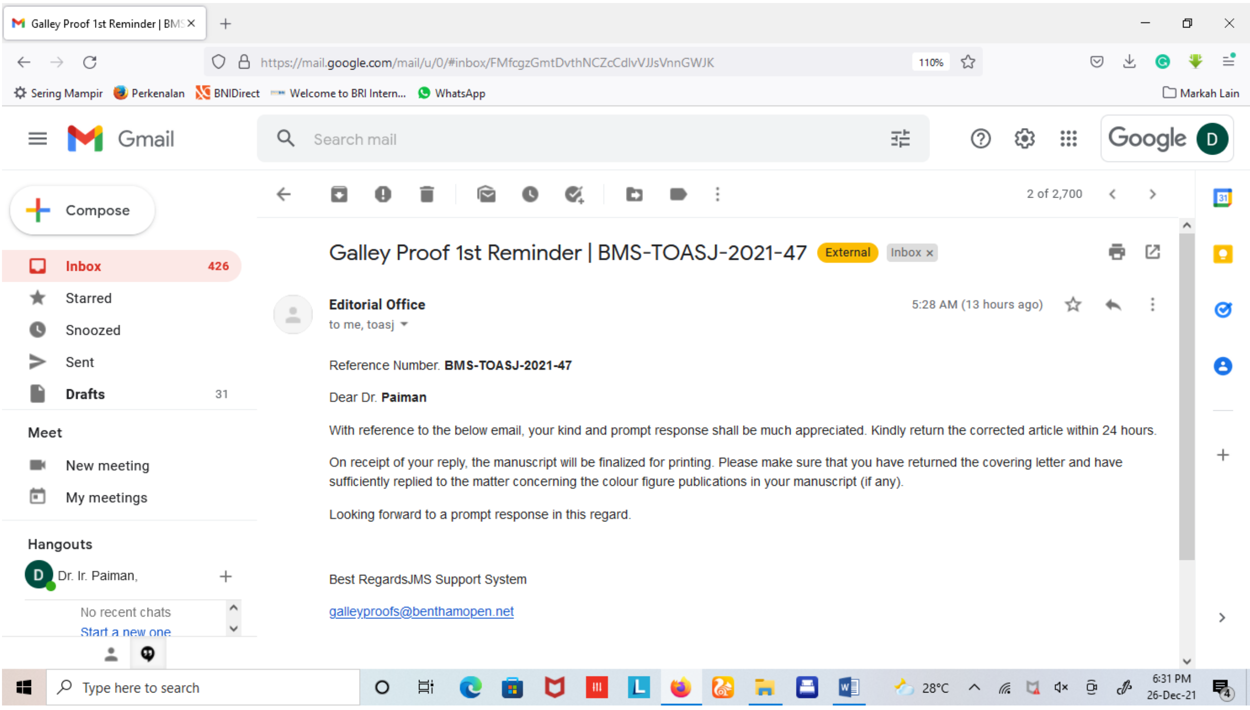

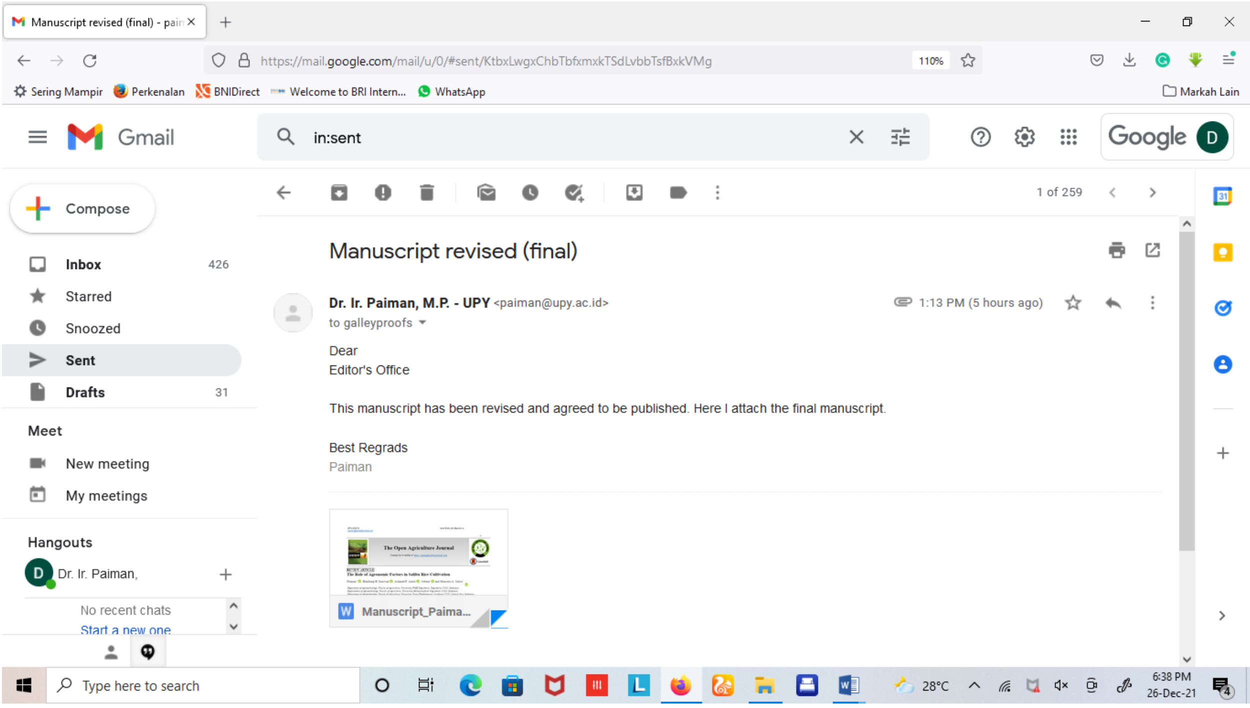

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REVIEW ARTICLE

The Role of Agronomic Factors in Salibu Rice Cultivation

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Abstract:

Background:

Salibu rice cultivation is one of the technologies that have been developed in Indonesia but not continued. This technology has great potential to increase land productivity. The unsustainability of the salibu rice cultivation is due to the lower yield than the parent rice. Not many farmers are aware of the agronomic factors that can increase the growth and yield of the salibu rice.

Objective:

This review article aims to explore the role of agronomic factors in salibu rice cultivation.

Results:

The review article shows that agronomic factors play a major role in salibu rice cultivation. The soil water availability for one year could be determined by the number of stages of SR cultivation. Two weeks before and after harvesting parent rice, soil water content should be estimated in terms of field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 days after harvest are the right SR cultivation methods. The fertilizer dose should be taken according to site-specific recommendations. 40% fertilization should be carried out at 14-21 days after stem cuttings, and the second at 60% at 30-40 days after stem cuttings in salibu rice cultivation.

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I. 1. INTRODUCTION

Various innovations are continuously made to increase national food self-sufficiency and farmers' income. One of the innovations is using salibu rice (SR) cultivation technology. Salibu is an abbreviation from '*salin ibu*' (change parent in English). However, SR cultivation has been developed in various Indonesian regions but has not received a good response from farmers. As a result, SR cultivation is stagnant in Indonesia. Indeed, SR production is considered less effective

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than the transplanting system (TS). The low production as a result of using this method is because farmers are not aware of the impact of agronomic factors on the growth and yield of SR.

Rice is a food crop that has been cultivated from generation to generation by Indonesian farming communities. The technology of SR cultivation is more efficient in cost and labor than the TS because it does not involve tillage, seeding, and planting. Not many rice farmers understand the benefits of using this technology. The SR cultivation can increase land productivity and farmer income, and increase cropping intensity, make efficient use of resources, and lower the production costs. According to Surdianto *et al*. [1], the SR is effective enough to be developed so that farmers can have the opportunity to adopt this technology to increase the cropping index and rice production.

The SR cultivation provides hope as a climate-smart technology and resource. The SR provides an opportunity to increase harvest intensity per year because the growth duration is shorter than the parent rice. Besides, it can be cultivated with less than 50% labor, 60% lower water availability, and lower production costs than the parent rice [2]. The effectiveness of water use in SR cultivation is also higher [3]. This technology is feasible to be developed because it has a benefit-cost ratio >

1. The SR cultivation has a short crop maturity period (a decrease by 45.66%), thus it is a technological breakthrough to anticipate climate change (drought) [4].

According to Erdiman *et al*. [5], the harvest age of the main crop could be ten days earlier than TS to be prepared as parent SR. The activity differences in SR and TS are presented in Table **1**.

II. TABLE 1. THE ACTIVITY DIFFERENCES IN SR AND TS CULTIVATION.

Activity	Cultivation System	
	SR	**TS**
Land preparation	Stem cuttings after TS harvest	Cleaning the leftover straw
Soil tillage	-	Plowing and harrowing
Seeding	-	Yes
Planting	-	Yes
Fertilization	Following site-specific recommendations and increase in N (25-50%)	Following site-specific recommendations
Thinning and embroidery	20-25 days after stem cuttings (DASC) of parent rice	25-30 days after planting (DAP)
Maintenance	Standard of plant pests	Standard of plant pests
Harvest age	20% earlier than the age of TS harvest	Following harvest age

Note: - = No activity, SR = Salibu rice, and TS = Transplanting system. Source: Erdiman *et al*. [5].

Table **1** shows that SR requires no soil tillage, seeding, and planting, so SR involves more efficient use of labor than TS. N fertilizer should be increased to stimulate vegetative growth because the SR lifespan is shorter. The first and second fertilization is done earlier than the TS. The harvest age of SR is 20% faster than TS.

The SR cultivation has not been much in demand by the farming community because of its low production. The slow development of this technology was due to the lack of information on its results due to which the farmers did not dare to speculate about trying SR cultivation. A study focused on the agronomic factors affecting the growth and yield of SR needs to be carried out. Thus, SR cultivation could be developed again to maintain food production in Indonesia. A literature review is necessary to provide complete information regarding SR cultivation. This review article aims to explore the role of agronomic factors in SR cultivation.

2. SALIBU RICE

The first SR was developed in West Sumatera (Indonesia). SR is a form of local wisdom-based technology that can solve the increasing need for food in Indonesia. Its harvest life is shorter than the parent rice, so it is possible to harvest four times in one year. Appropriate technology for rice harvesting is needed to increase time efficiency. According to Hasan *et al*. [6], the application of appropriate technology for rice harvesting in developing countries is urgently needed to increase cropping intensity, crop productivity, and reduce time, effort, and input costs.

SR is a modification of rice cultivation from ratoon rice. The stem cutting of the parent rice shorter or closer to the soil surface is more suitable for SR cultivation technology [7]. SR grows from the remaining stems that are cut after harvest. New shoots emerge from the remaining stems near the soil surface and form new roots. Initial growth and strength of tiller formation depend on the carbohydrate reserves of the stem and root of the parent rice.

Furthermore, the tiller is supported by new leaves so that the supply of carbohydrates is no longer dependent on the previous parent plant. The shoots then form new tillers again like TS.

The growth and yields of SR are influenced largely by rice variety [8]. The superior varieties of seed are more important and beneficial for rice productivity [9]. In the selection of parent rice seeds, superior varieties with high production and short life are prioritized. Short-lived types can increase the cropping index. Superior varieties with high production, resistance to pests and diseases, and tolerance to abiotic problems can increase the rice yields. According to Bui *et al.* [10], tolerant varieties have higher survival rates and less shoot elongation but longer root elongation during immersion compared to sensitive varieties.

According to Sastro *et al*. [11], several inbred and hybrid rice have high production and shorter harvest lives in Indonesia; the superior rice varieties are shown in Table **2**.

III. TABLE 2. LIST OF SUPERIOR VARIETIES OF INBRED AND HYBRID RICE IN INDONESIA.

Superior Varieties	**Harvest Age (Days)**	**Average Yields (ton ha^{-1})**	**Potential Yield (Ton ha^{-1})**
Inbred Rice:			
Inpari 11	105	6.5	8.8
Inpari 13	99	6.6	8.0
Inpari 18	102	6.7	9.5
Inpari 19	104	6.7	9.5
Inpari Sidenuk	103	6.9	9.1
Padjajaran Agritan	105	7.8	11.0
Cakrabuana Agritan	104	7.5	10.2
Hybrid rice:			
Hipa 10	114	8.1	9.4
Hipa 11	114	8.4	10.6
Hipa 12 SBU	105	7.7	10.5
Hipa 13	105	7.7	10.5
Hipa 14	112	8.4	12.1
Hipa 18	113	7.8	10.3
Hipa 19	111	7.8	10.1

Source: Sastro *et al*. [11].

Table **2** shows that the production of hybrid rice is higher than inbred rice. The hybrids in Indonesia have a potentially high production rate and shorter harvest age. The hybrid rice of Hipa 10, Hipa 11, and Hipa 14 can be used as the parent rice. These superior varieties, as parent rice, are expected to reduce high-producing genetic traits. Lardi *et al*. [8] stated that under natural conditions, plant growth is largely determined by the plants' genetic factors, especially the condition of growth regulators (hormones). According to Liu *et al*. [12], SR growth is influenced by the growth of parent rice, so it can be evaluated by determining parent rice-growing conditions.

The yield of grain in SR plants is a complement to the parent rice [13]. The high yield of hybrid rice is due to the increased harvest index. The hybrids significantly exhibit higher productivity than those cultivated in the dry season, but the difference is not significant in the wet season. Hybrids produce spikelet panicle^{-1} and 1000 grain dry weight higher than inbred rice [14]. The ratoon yield of the hybrids is better than inbred. The average result is 75.2% of the parent rice [15]. Short-lived varieties are more profitable [16]. Ratoon yields are higher using hybrid than inbred rice [17]. Utilization of the hybrid ratoon rice in androgenetic conditions will save cultivation time and costs [18].

Rice production is influenced by some factors, such as varieties, management, and environments. Among the environmental factors are agronomic traits and climate [19]. Land-use efficiency forms must be developed continuously [20]. Land is a key factor in production agriculture [21]. Rice as a perennial crop produces a stable and sustainable grain yield over successive seasons across years [22]. Hybrid rice involve higher productivity and profitability [23]. Besides, agricultural technology innovation is an important factor in supporting increased rice production [24]. The efforts of SR cultivation are made to increase land productivity in order to meet food needs through SR cultivation. Rice crops can be cultivated many times a year by SR cultivation, thereby increasing land productivity. Agronomic factors play a big role in increasing SR production.

3. AGRONOMIC FACTORS

3.1. Availability of Soil Water

SR allows rice harvests to be carried out 3.5–4 times a year with yields equivalent to the parent rice [7]. The increasing harvest index depends on the water availability conditions. According to Negalur *et al*. [2], SR has a short growing duration, suitable in rainfed areas with residual soil moisture. Rainfed rice fields can be planted once or twice in harvests, making planning difficult depending on the unpredictable rainwater. Harvesting can be done 3-4 times a year on semi- technical rice fields and fields involving technical irrigation. The cropping system patterns of TS (1st stage), SR (2nd stage), and SR (3rd stage) are more profitable than TS (1st stage) and TS (2nd stage) in one year.

The selection of rice varieties is better determined by water conditions in the field [25]. Increasing land productivity is a determining factor for rainfed rice farming [26]. Rice breeders regard ratooning as an important practice for sustainable rice production in tropical agricultural systems to maximize profits [27]. Rainfed land has important benefits in increasing food production. TS is better than the seed-direct system as it takes advantage of residual soil moisture [16]. Rice cultivation in rainfed lowland can increase from one to two harvests using the TS (1st stage) and SR (2nd stage) in a year.

The soil moisture content influences the main crop harvest [28]. The inundation height of 5 cm from the soil surface results in taller plants and more tillers than the saturated condition treatment with a 0.5 cm water layer [29]. Saturated conditions up to 1 cm in height can be applied in rice cultivation by farmers, which will not affect rice production and soil characteristics [30]. Ratoon rice yields show that inundation (full flooding) provides the highest yield than inundation intervals of 2, 4, and 6 days [31].

In contrast to the findings presented by Elkheir *et al*. [32], each soil type essentially conserves water due to which fields show better rice production under aerobic conditions. According to Bleoussi *et al*. [33], the protein content of each rice variety increases with increasing drought intensity. The groundwater deficit has significant implications for grain quality. Momolu [34] stated that grain yields for all rice cultivars decrease with the formation of tillers due to the extended stress period.

The rice field ecosystem is divided into lowlands, highlands, and water. Rice ratooning is more suitable for lowland rice fields [35]. The SR cultivation can be done on rainfed land, although it can be done in two stages, TS (1st stage) and SR (2nd stage), due to the limited availability of soil water. Barnaby *et al*. [36] stated that rice plants have a variety of physiological and metabolic strategies in producing tolerance to water stress. It is necessary for rice varieties selection that is adaptable to deficit irrigation production systems or less water. The model of SR cultivation pattern is presented in Table **3**.

IV. TABLE 3. THE MODEL OF SR CULTIVATION IN RICE FIELDS.

Rice Fields Types	Generation of the Rice Plant			
	TS (1st Generation)	**SR (2nd Generation)**	**SR (3rd Generation)**	**SR (4th Generation)**
Rainfed land	ϴ	√	-	-
Semi-technical irrigated land	ϴ	√	√	-
Technical irrigated land	ϴ	√	√	√

Remarks: TS = Transplanting system, SR = Salibu rice, ϴ = TS cultivation, √ = SR cultivation, and - = No cultivation.

Table **3** shows that soil water availability for one year will determine the number of SR cultivation stages. In semi- technical irrigated land, it can be increased to 3 harvests per year with the patterns, TS (1st stage), SR (2nd stage), and SR (3rd stage). In comparison, on technical irrigated land, it can be increased to 4 rice harvests a year with the patterns, the TS (1st stage), SR (2nd stage), SR (3rd stage), and SR (4th stage). The SR can be cultivated more than four times from one planting of parent rice.

3.2. Time and Height of Stem Cuttings

The SR cultivation is better implemented in a land that is not always inundated [37]. During two weeks before and after harvest, soil water content should be maintained according to field capacity. Initial shoots growth of SR is better if the field capacity conditions are maintained rather than inundated. Rice varieties' ability to produce the number of shoots or tillers after cutting the stem of main rice depends on genetic and environmental characteristics, including soil water content availability. Shiraki *et al*. [38] stated that soil moisture conditions two weeks before and after the harvest significantly affect grain yield. Ratoon plants in dry soil moisture conditions can increase yields by 69% than humid or flood conditions. According to Oda *et al*. [39], late irrigation is recommended in ratoon rice management practices.

Cutting of the stem at physiological maturity provides the best ratoon yield [40]. Rice yields are proportional to the number of ratoon tillers produced. The late stem cuttings have the most effect on the ratoon tillers number [39]. The shorter stem cutting causes the ratoon growth to be longer at the vegetative stage of growth, and delays the maturity stage of the grain [41]. Cutting height significantly influences plant height, the number of grains per panicle, and filled grains. Fitri *et al*. [7] showed that the optimal results for the number of productive tillers, the number of seeds per panicle, and rice productivity are obtained when the remaining stems are cut at the height of 3-5 cm above the soil surface, and carried out at the age of 7-8 days after harvest (DAH).

The main crop's first harvest is done at 5 cm of cutting height [42]. Carbohydrates are needed to maintain metabolic activity during the initial growth stages. The remaining stems provide the energy requirements for new tillers' growth after cutting, and then the tillers immediately become autotrophic [8]. The highest yield of ratoon rice (Ciherang variety) is achieved when stems are cut at harvest with a height of 3 cm above the soil surface with a grain yield of 3.54 tons ha^{-1} [43]. The effect of cutting height on rice yields depends on the photosynthetic conditions and the number of internodes remaining in the main stem as a place for ratoon shoots to appear [44].

There are differences in the dynamics of shoot growth at the stem nodes. The morphology of vegetative organs shows that hormones regulate shoot growth on the main stem nodes. There are several proteins involved in brassinosteroid biosynthesis. Brassinosteroid signaling plays a role in the germination of axillary buds of ratoon rice [45]. The ability of rice crops to produce ratoon is strongly influenced by the carbohydrate and phytohormone content left in the stem meristem tissue after harvest [46]. If the stems' cutting is done 2-3 cm from the soil surface, the new germin shoots could be reproduced to form the next new rice tiller. The difference in the emergence of new shoots on the parent stem can be seen in Fig. (**1**).

In higher cutting (Fig. **1a**), new lateral shoots emerge from the upper stem node. Taller stem cuttings produce more new shoots, and soon, new leaves form. Shoots have a short vegetative growth so the leaves number is small and the leaf area size is narrow, and they immediately move into the reproductive phase. In lower stem cutting (Fig. **1b**), new shoots grow from the basal stem. The shorter stem cuttings cause new shoots to grow in the soil surface that immediately form new roots, producing new tillers. Rice tillers have a more extended vegetative growth phase and produce more leaves extending to a broader area. The leaf area affects the photosynthesis process, producing carbohydrates.

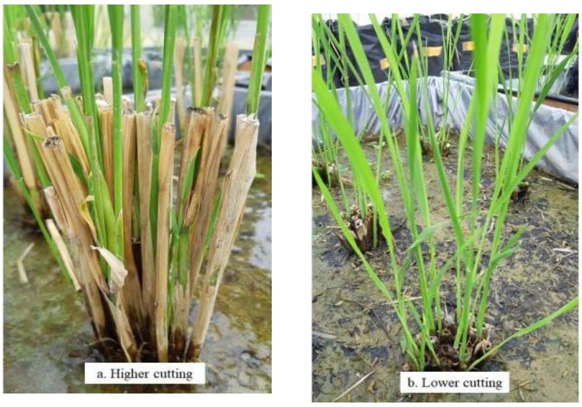

Fig. (1). The emergence of new shoots on the remaining stems with different cutting heights in 14 DASC.

The ratoon tillers are related to the level of stem carbohydrates at harvest time [28]. Higher stem cuttings cause the plant to grow and flower quickly because the shoots take advantage of the remaining carbohydrate reserves in the stem of the parent plant. In contrast to shorter stem cuttings, new shoots are formed to produce new roots. Furthermore, new shoots arise from the next new tillers so the vegetative life is longer. Mareza *et al*. [44] indicated that the lower stem cuttings cause the tiller number per clump to be lower and more productive. The number and leaves area per tiller^{-} is more wider, but the leaf area per clump is lower. Also, stem cutting results in longer flowering age and harvesting, higher dry weight of the tillers, and the same seed carbohydrate content as the parent plant, but plant dry weight per clump is lower.

3.3. Dose and Time of Fertilization

The regrowth of tillers depends on the carbohydrate reserves in the plant stems or roots remaining after pruning. The carbohydrates are needed to maintain metabolic activity during the initial stages of regrowth. The energy is required to supply new tillers that immediately become autotrophic [47]. Furthermore, after the shoots grow, it takes a sufficient supply of nutrients from the environment to support normal growth like the previous parent rice. Nutrients in the soil during the harvest of the main crop greatly affect the performance of the shoots.

The growth and yields of SR are primarily influenced by the balanced nutrients [8]. Better yields of ratooned crops are possible by increasing fertilization, mainly the supply of nitrogen [46]. SR age is shorter than the parent rice, so a balanced fertilization system is needed to strengthen its vegetative growth. Nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) are the primary nutrients for increasing and sustaining SR productivity.

The urea fertilizer application can increase the N element in the soil. The N availability can cause plant leaves to look greener, the number of tillers to be more, accelerate the growth of shoots, roots, photosynthesis, and stimulate rice plants' growth. According to Ambarita *et al*. [48], the excessive N application can be inhibited by the absorption of other elements, which may lead to decreased growth and yield and increased amount of empty grain. Mamun *et al*. [49] showed that using an additional 25% nitrogen of the recommended dose for ratoon crops after harvesting the main crop can yield economic yields for hybrid rice.

In a study, fertilizer application was done in 3 stages. The first fertilization was applied at 10 DAH (20% of urea dose), the second at 21 DAH (40% of urea dose), and the third at 35 DAH (40% of urea dose). The dose of 375 kg ha^{-1} urea application significantly affected the increase in the number of tillers (32.06 tillers $clump^{-1}$), the number of panicles (18.86 units $clump^{-1}$), and grain dry weight (0.63 kg m^{-2}) in SR cultivation of Ciherang variety [50]. The dose of 50 kg ha^{-1} urea and 50 kg ha^{-1} NPK Phonska fertilizer did not significantly affect rice production between the three zones of high, medium, and lowland on the Salibu system [7]. NPK Phonska is an inorganic fertilizer with the name NPK compound fertilizer consisting of several macronutrients, such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). The content of NPK Phonska 15-15-15 is N (15%), P_2O_5 (15%), K (15%), and S (10%). Rice farmers widely use this fertilizer because it can increase the yield and grain quality.

An increase in nitrogen dose within a certain range is followed by an increase in leaf area index, plant height, number of tillers, net photosynthesis rate, transpiration rate, and grain yield. In addition, the effect of increasing nitrogen dose on grain yield index and nitrogen contribution rate are parabolic [51]. The dosage of nitrogen fertilizer has a different effect on the number of tillers per clump, the percentage of filled grains per panicle, and the weight of 1000 grains [52]. The vegetative age of SR is shorter than the parent plant. A delay in fertilization can lead to fewer tillers and decreased grain yields. Rice plants must absorb sufficient N, P, and K during the growth stage to obtain optimal growth characteristics and yields [53]. Fertilization of SR is carried out according to site- specific recommendations. According to Kristamtini *et al*. [4], the dose of fertilizer application should comply with recommendations from paddy soil test equipment and be given in two times. The first fertilization should be done at 40% of the recommended dose at 15-20 days after stem cuttings (DASC). The second fertilization should be as much as 60% of the recommended dose at 30-35 DASC. Suparwoto and Waluyo [54] reported, in their study, the first fertilization at 14 DASC by applying 150 kg ha^{-1} urea fertilizer and the second at 40 DASC with 25 kg ha^{-1} SP-36 and 25 kg ha^{-1} KCl fertilizers.

Based on the results of previous studies, a summary of the dose of fertilizer and time of fertilization in the cultivation of SR can be made. For more details, this summary is shown in Table **4**.

Table **4** shows that the dose of fertilizer and the time off ertilization vary. Therefore, it is necessary to research on the type and dose of fertilizer and the right time of application. Even though there is no recommendation for site-specific fertilization, SR cultivation is still profitable compared to TS from the farming aspect.

V. TABLE 4. THE DOSE AND TIME OF FERTILIZATION IN SALIBU RICE CULTIVATION.

Dose of fertilizer	Time of fertilization	References
Recommendations from paddy soil test equipment	The first fertilization was applied as much as 40% of the recommended dose at 15-20 DASC, and the second involved 60% of the recommended dose at 30-35 DASC.	Kristamtini *et al*. [4].
375 kg ha^{-1} urea	The first fertilization was applied at 10 DAH (20% of urea dose), the second at 21 DAH (40% of urea dose), and the third at 35 DAH (40% of urea dose).	Safrudin [50].
150 kg ha^{-1} urea, 150 kg ha^{-1} SP-36, and 25 kg ha^{-1} KCl	The first fertilization was applied at 14 DASC (150 kg ha^{-1} urea), and the second at 40 DASC (150 kg ha^{-1} SP-36, and 25 kg ha^{-1} KCl).	Suparwoto and Waluyo [54].

The SR has been found to be more profitable than TS. The farmers save the costs of the production process in the second planting season. Production activities, such as plowing, harrowing, nursery, seedlings removal, planting, and purchasing seeds, are not carried out. According to Surdianto *et al*. [1], the comparison of costs between SR and TS is shown in Table **5**.

VI. TABLE 5. THE COMPARISON OF COSTS BETWEEN SR AND TS.

No.	Cost description	Total (Rp. ha^{-1})		Cost difference (Rp. ha^{-1})
		SR	TS	
1.	Labor cost	(6,083,333)	(7,790,000)	1,706,667
	Nursery	-	330,000	
	Soil tillage	-	1,300,000	
	Planting	-	1,200,000	
	Stem cuttings	660,000	-	
	Maintenance (stitching, weeding, fertilization, and spraying)	3,440,000	2,720,000	
	Harvest and thresh	1,983,333	2,240,000	
2.	Cost of production facilities	(4,455,000)	(4,623,000)	168,000
	Seeds	-	480,000	
	Anorganik fertilizer	1,145,000	1,505,00	
	Manure fertilizer	1,680,000	900,000	
	Pesticide	1,630,000	1,738,00	
1 + 2	Total	10,338,333	11,483,000	1,874,667

Remarks: - = No activity, SR = Salibu rice, and TS = Transplanting system. Source: Surdianto *et al*. [1].

Table **5** shows that the cost difference between the SR and TS is Rp. 1,874,667 ha^{-1} for each growing season. It means that the SR cultivation system can increase farmers' income and production costs can be eliminated.

VII. CONCLUSION AND RECOMMENDATION

The literature reviewed above shows that the development of SR cultivation in Indonesia is slow, but it can be improved again. Farmers need to apply the agronomic factors that affect the success of SR cultivation. The soil water availability for one year can determine the number of stages of SR cultivation. Two weeks before and after harvesting parent rice, soil water content should be maintained according to field capacity. Stem cuttings as high as 3-5 cm from the soil surface at 7-8 DAH are the right method for SR cultivation. Fertilizer dose needs to be determined according to site-specific recommendations. The first fertilization should involve 40% of the recommended dose at 14-21 DASC, and the second as much as 60% at 30-40 DASC. The soil water availability, time and height of the stem cuttings, and dose and time of fertilization affect the SR cultivation. Three agronomic factors need to be applied by farmers in SR cultivation.

VIII. LIST OF ABBREVIATIONS

DAH = Days After Harvest

DAP = Days After Planting

DASC = Days After Stem Cuttings

N, P, K, S = Nitrogen, Phosphorus, Potassium (K), and Sulfur

SR = Salibu Rice

TS = Transplanting System

IX. CONSENT FOR PUBLICATION

Not applicable.

X. FUNDING

Not applicable.

XI. CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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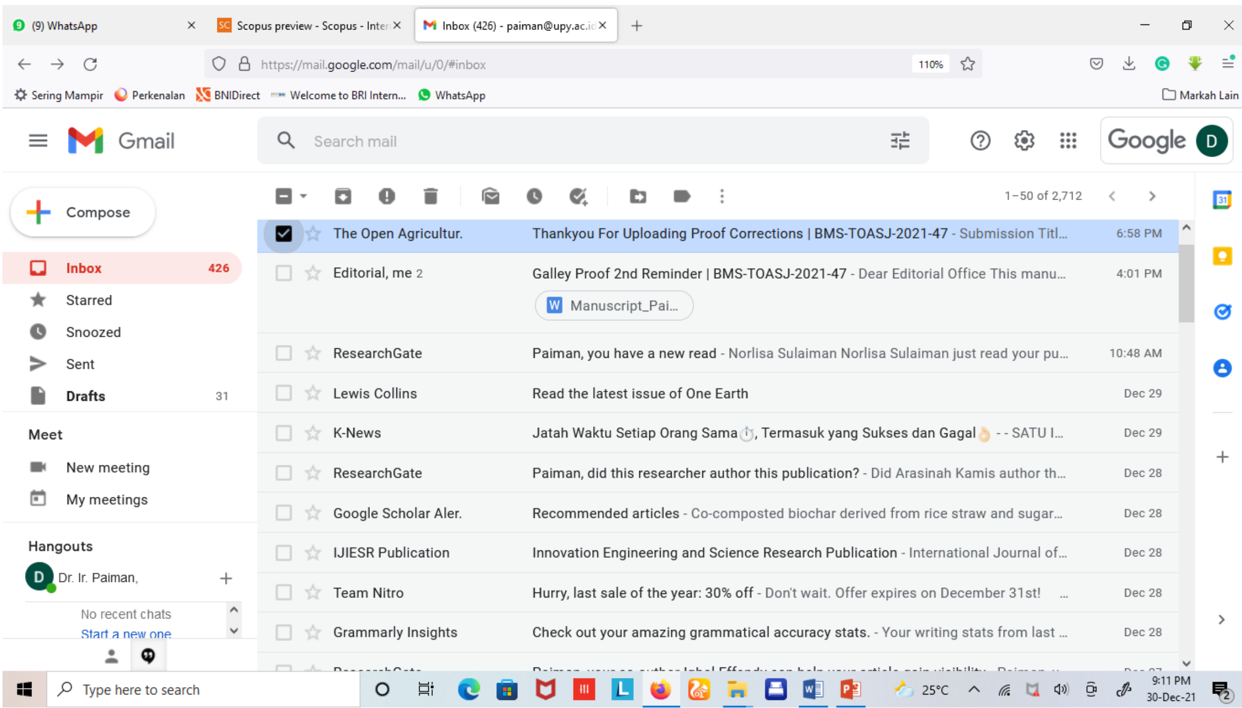
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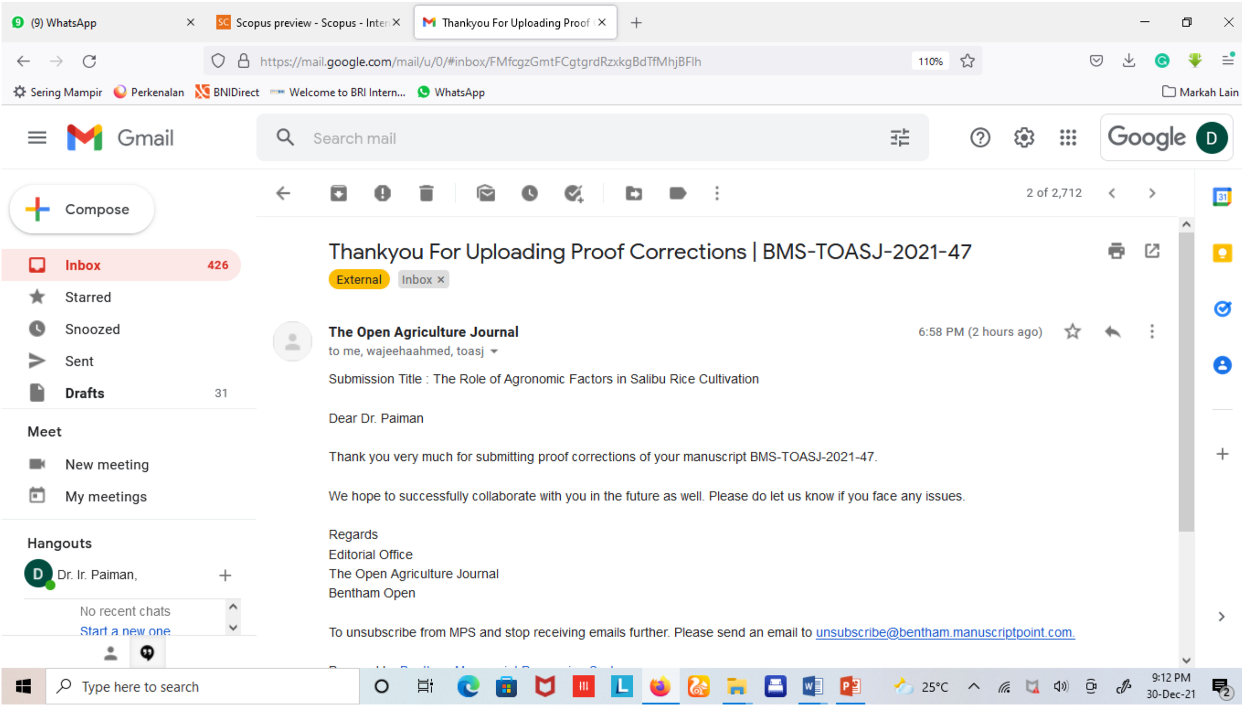

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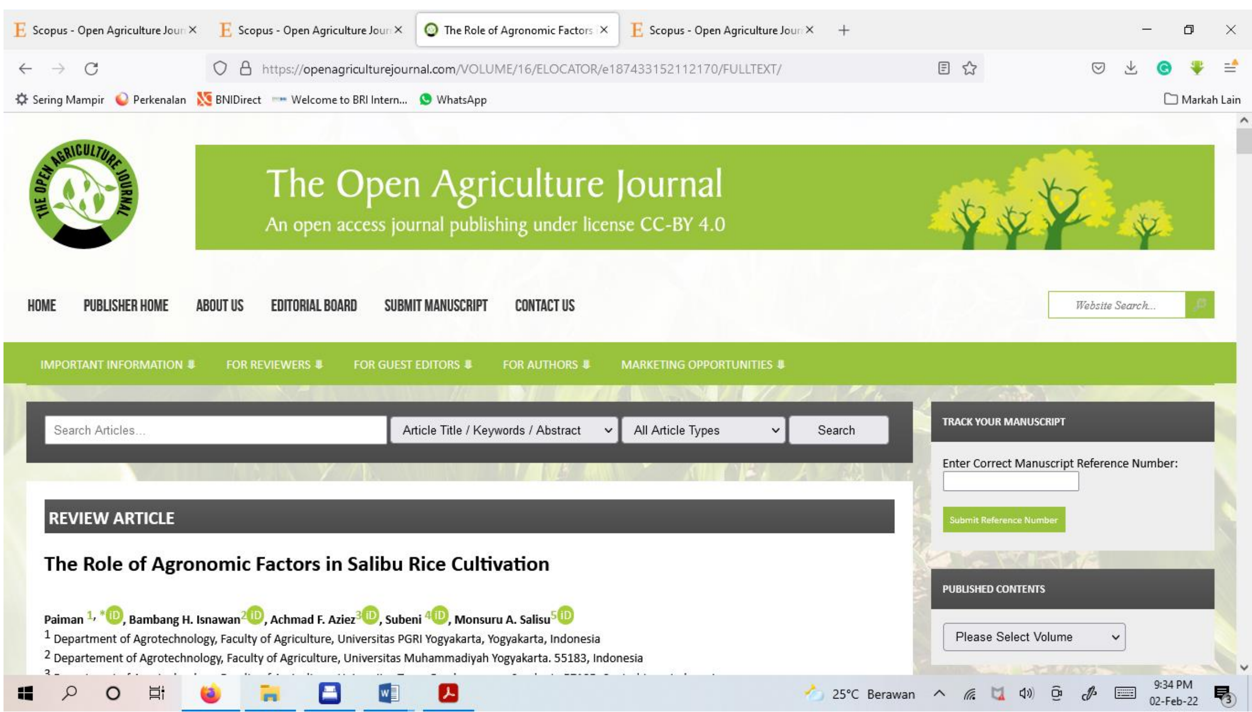

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REVIEW ARTICLE

The Role of Agronomic Factors in Salibu Rice Cultivation

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