

Vegetative physiological and yield components observation of rice varieties with specific plant spacing in integrated mature-4 by smallholder of oil palm.

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ORIGINAL RESEARCH PAPER

VEGETATIVE, PHYSIOLOGICAL, AND YIELD COMPONENTS OF RICE VARIETIES ON SPECIFIC PLANT SPACING IN INTEGRATED WITH MATURE-4 OF SMALLHOLDER OIL PALM

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ABSTRACT

The research was aimed to obtain the vegetative, physiological, and yield components of several varieties of lowland rice with specific plant spacing in integrated with mature-4 of smallholder oil palm. This research was conducted at Titi Payung street, Hamparan Perak Subdistrict, Deli Serdang District, North Sumatra Province, Indonesia in April until August 2017. This research was used the split-plot design with the main-plot is the plant spacing ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plots is the rice varieties ($V_1 = \text{Inpara 2}$; $V_2 = \text{Inpari 4}$; $V_3 = \text{Inpari 10}$; and $V_4 = \text{Inpari Sidenuk}$). Parameters were analyzed by ANOVA and the means effect was followed by DMRT 5%. The results were showed that the Inpari Sidenuk variety significantly increased the grain yield.plot⁻¹ and the highest yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of 25 cm x 25 cm (J_2), 25 cm x 30 cm (J_3), and 25 cm x 35 cm (J_4) can

significantly increase the fresh weight stover.clump⁻¹ of 13.53 g;

13.29 g; and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm can increase the panicle length, number of grain.panicle⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm has the potential to be recommended in integrated with mature-4 of smallholder oil palm to increasing yield and food self-sufficiency. Keywords: integration, plant spacing, rice varieties, smallholder oil palm.

INTRODUCTION

The lowland rice yield in Indonesia over the past 5 years (2014-2018) has fluctuated (BPS Indonesia, 2019). One of the provinces in Indonesia as a contributor to rice yield is North Sumatra Province, however, the lowland yield is classified as fluctuated from 2006- 2018 (Figure 1). The lowland rice yield fluctuated can be caused by the rice area also has fluctuations (BPS Sumatera Utara, 2019). The decrease in the area of lowland rice harvesting can be caused by the conversion of lowland rice to oil palm plantations. The conversion of lowland rice to plantation plants such as oil palm and rubber. According to Anggari et al., (2016) the cause of the public (a case study of Trumon Subdistrict, South Aceh District) executes the conversion of lowland rice into oil palm plantations such as the risk in lowland rice farming is higher, and economic factors are more profitable. Fauzi, (2005) stated that the lowland rice conversion is the lack of certainty in the price of lowland rice so that the income from rice is lower compared to oil palm and rubber plantation.

The decrease in the lowland rice land will have an impact on the deficit of rice stocks in Indonesia. Rice demand in 2025 is expected to increase by 60%. In supply to food demand then the government through the ministry of agriculture has been focusing on seven major commodities in the program to achieve self-sufficiency and increased yield at the 2017 year

through the program UPSUS PAJALE and plans to form 1 million hectares of lowland rice land until 2019 year (Nuryati et al., 2015).

The effort to form 1 million hectares of lowland rice need to be supported by the use mature of oil palm plantations through the program integration of lowland rice with oil palm plants. The application of lowland rice as intercropping among oil palm has been reviewed by previous researchers without harming the plantations. Bratkovich et al., (1993) stated that the oil palm can survive in flooded up to 3 months. Colmer and Voeselek, (2009); Dewi, (2009) reported that the oil palm is classified as very tolerant of flooded. Holidi et al., (2015) stated that the oil palm can survive in inundation conditions up to 50 days. The results showed that oil palm in flooded conditions is very beneficial for the growth and development of lowland rice with $\pm$ 3 months to harvest.

Therefore the existence of previous research, it is expected that lowland rice plants will also be able to grow and produce until harvesting even though some shaded by oil palm canopy. However, lowland rice in the conditions of shaded will experience disruption of physiological and biochemical processes. Chozin et al., (1999) stated that one of the inhibitors to the growth and production of upland rice in intercropping is the occurrence of light deficits reaching the rice canopy. Low light intensity results in disruption of the rate of photosynthesis and carbohydrate synthesis and results in a decrease in the rate of growth and yield of plants.

Therefore several alternatives are needed to increase the yield of lowland rice with the integration of oil palms including the use of shade-tolerant varieties and plant spacing. It is very difficult to find publications and references of research results with the planting system of lowland rice in the oil palm plants. According to Murty dan Sahu, (1987); Cabuslay et al., (1991); Lubis et al., (1993) planting upland rice in the immature of oil palm area as land use can reduce yield by up to 70 until 90% in shade conditions $>$ 50% compared to normal light. Warjido et al., (1990) stated that the plant spacing is important in optimizing the use of

sunlight for photosynthesis, with the result that plants will have balanced growing space.

Magfiroh et al., (2017) stated that the plant spacing of 25 cm x 25 cm can significantly increase panicle length and the number of grain.panicle⁻¹ of lowland rice of 3.60% and 8.71%, respectively compared to plant spacing of 20 cm x 20 cm.

The selection of lowland rice varieties has an important role in determining optimal yield in shaded conditions. Some varieties that can be recommended in the cultivation of lowland rice released by the Ministry of Agriculture include Inpara 2, Inpari Sidenuk, Inpari 10, and Inpari 4 with an average yield of 5.49; 6.60; 6.00; and 6.04 tons.ha⁻¹, respectively. Therefore further research is needed on the use of several varieties of lowland rice that can yield in oil palm to support national food security. The purpose of this research was to obtain high-yielding lowland rice varieties at plant spacing with integrated mature-4 of smallholder oil palm.

MATERIAL AND METHODS

Land Management

The research integration of lowland rice and mature-4 of oil palm oil with the number population of 72 trees (0.50 ha) which is located at Titi Payung street, Hamparan Perak Subdistrict, Deli Serdang District, North Sumatra Province, Indonesia in April until August 2017. This research conducted with the processing of the land using the hand tractor. The soil was cultivated three folds as deep as 20 cm, using the rotary plow.

Plot Size and Research Design

The plot was made with a size of 10 m x 20 m. This research used the split plot design with the main-plot is the plant spacing of 4 levels ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plot is lowland rice varieties consisting of 4 varieties, namely ($V_1 = \text{Inpara 2}$; ($V_2 = \text{Inpari 4}$; ($V_3 = \text{Inpari 10}$; and ($V_4 = \text{Inpari Sidenuk}$). The treatment of this research was used the three replications.

Seeding and Planting Process

Seed rice was soaked in water for 24 hours and then drained for 12 hours. The seeds that have germinated are then sown in the nursery and after 2 weeks were moved to the plot. After the seedlings are 3 weeks and planting was conducted in the plot following the treatment in manually, each hole only one plant. The number of plants in the sub-plot was 24 plants with 5 plant samples.

Plant Management

The transfer of seedlings, water has flowed into the plot with a height of 5 cm until the plant is 45 days old. The insertion was performed during 2 weeks after planting (WAP) or before the basic fertilization. Weeding was conducted in the initial period until 21 and 42 WAP used the manually when weeds have 3-4 leaves, then flooded for 1 day. Fertilization was conducted with N 90 kg.ha⁻¹, TSP 50 kg.ha⁻¹, and KCl 50 kg.ha⁻¹. The phosphorus and potassium fertilizer are given as basic fertilizers and given before transplanting seedlings, while N fertilizer is given 3 folds such as a week after transplanting, 40 days after transplanting and 65-70 days old. Pest and disease control is only conducted when the symptoms of an attack have reached the economic threshold using insecticides, and fungicides that are adjusted to pests/diseases.

Harvesting

Two weeks before harvesting the lowland rice water is drained so that the rice grains mature quickly. Harvesting was conducted manually using the sickle at the mature plant physiology marked visually in lowland rice, such as rice grains were yellowed ranged from 90 until 95% or grain moisture content ranges from 22 until 27%.

Parameters and Analysis

Data Vegetative

Components

The parameters of the vegetative components such as plant height (cm), number of tillers, and leaf area (cm²). Plant height and number of tillers were measured at 4 and 6 WAP.

Leaf area was measured at harvest by taking a flag leaf from each sample and calculated by the formula $p \times l \times 0.75$.

Physiological Components

The parameters of the physiological component such as leaf chlorophyll content (chlorophyll a, b, and total), fresh weight stover.clump⁻¹ (g), and dry weight stover.clump⁻¹ (g). The chlorophyll a, b, and total were measured using the UV-Vis spectrophotometer (Hendry and Grime, 1993). The extraction of chlorophyll was conducted with acetone 80%, the leaves are weighed 0.1 g, then crushed in the mortar, inserted 10 ml acetone, filtered with Whatman filter paper. The filtrate was measured for absorbance at 645 nm and 663 nm. The calculation of chlorophyll a, b and total content using the formula:

$$\text{Chlorophyll a} = (12.7 \times A_{663} - 2.69 \times A_{645}) \times 10^{-1} \quad (1)$$

$$\text{Chlorophyll b} = (22.9 \times A_{645} - 4.68 \times A_{663}) \times 10^{-1} \quad (2)$$

$$\text{Chlorophyll total} = (8.02 \times A_{663} + 20.2 \times A_{645}) \times 10^{-1} \quad (3)$$

Fresh weight stover.clump⁻¹ was cut from the base of the stem at the end of the research, be weighed, then put into a brown envelope and dried in the sun for 3 days and oven at 60°C for 72 hours to obtain the dry weight stover.clump⁻¹ after which it was weighed using analytical scales.

Yield Component

The parameters of the yield component such as the number of productive tillers, panicle length (cm), number of grain.panicle⁻¹, filled grain (%), empty grain (%), 1000 grains weight (g), grain yield.plot⁻¹ (kg), and yield.ha⁻¹ (tons). The number of productive tillers was measured when the plants were flowered, by counting the tillers produce panicles. Panicle length was measured when the plant has been harvested by measuring the panicle formed.clump⁻¹ from the base to the end of the panicle. The number of grains.panicle⁻¹ was calculated by dividing the total number of grains in the sample with the total number of

panicles. The percentage of filled grains was calculated by dividing the number of filled grains from all panicles of the sample with the total number of grains. The percentage of empty grains was calculated by dividing the number of empty grains from all panicles of the sample with the total number of grains. The 1000 grains weight was measured by drying up to moisture content of 14% and take by 1000 rice grains randomly then weighed. The grain yield.plot⁻¹ was calculated by weighing the filled grain in each plot and weighed using analytical scales. The yield.ha⁻¹ was calculated by converting the average grain yield.plot⁻¹ using the formula:

$$\text{Yield/ha}^{-1} = \frac{\text{Average Yield.Plot}^{-1}}{\text{Plot Area}} \times \text{Area of 1 ha} \quad (4)$$

Parameters were analyzed with analysis of variance (ANOVA) and the significant effect was followed by Duncan's Multiple Range Test (DMRT) at the level of 5%.

RESULTS AND DISCUSSION

Vegetative Components

The results of the ANOVA showed that the varieties, plant spacing and their interaction not significantly influence the increase in plant height, number of tillers and leaf area of lowland rice in integrated with mature-4 of smallholder oil palm (Table 1).

The results showed that the plant height of lowland rice varieties was integrated with mature-4 of smallholder oil palm highest were found in the Inpari Sidenuk variety (V₄) of 70.85 cm and 90.36 cm, respectively at 4 and 6 WAP. The plant spacing of 25 cm x 35 cm (J₄) is the spacing that the highest of plant height amounted to 68.90 cm and 87.26 cm, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in Inpari 4 variety (V₂) of 7.15 tillers and 12.23 tillers, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 30 cm (J₃) of 7.18 tillers at 4 WAP, and found in 25 cm × 35 cm (J₄)

of 12.08 tillers at 6 WAP. The leaf area of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the Inpari Sidenuk variety (V_4) of 26.27 cm^2 , and plant spacing of $25 \text{ cm} \times 25 \text{ cm}$ (J_2) amounted to 38.97 cm^2 .

Rice variety of Inpari Sidenuk (V_4) and plant spacing of $25 \text{ cm} \times 25 \text{ cm}$ (J_2) in integration with mature-4 of smallholder oil palm can adapt to the low light intensity, this is evidenced by the highest leaf area compared to the others treatment. According to Levitt, (1980) an adaptation of plants to shade can be conducted through avoidance that is associated with response to changes in the anatomy and morphology of leaves for photosynthesis efficient. The efficiency of increasing light capture can be conducted by increasing the area of light capture, by increasing the leaf area. Yeo, (1994); Santosa et al., (2000); Sopandie et al., (2006) stated that the low light in upland rice cause disturbed metabolic processes which have implications for decreasing the rate of photosynthesis and carbohydrate synthesis.

Physiological Components

The results of the ANOVA showed that planting spacing significantly increased the fresh weight stover.clump⁻¹, however not significantly increased the chlorophyll a, b, total, and dry weight stover.clump⁻¹ of lowland rice. Varieties and their interactions not significant effect in increasing the physiological component of lowland rice in integrated with mature-4 of smallholder oil palm (Table 2).

The results showed that the Inpari 4 variety had higher levels of chlorophyll a, b, and total of 3.57 mg.cm^2 , 4.54 mg.cm^2 , and 8.11 mg.cm^2 , respectively compared to other varieties. The chlorophyll a, b, and total of lowland rice varieties were integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of $25 \text{ cm} \times 35 \text{ cm}$ (J_4) of 3.59 mg.cm^2 , 4.59 mg.cm^2 , and 8.18 mg.cm^2 , respectively compared to other plant spacing. Lowland rice varieties are very tolerant of shading were showed that the change in morphological character (leaf area) as lower compared to sensitive varieties. The effect of

plant spacing of 25 cm × 35 cm (J₄) has an impact on the amount of light that can be absorbed by lowland rice because the spacing between plants is relatively wider compared to other plant spacing. Chozin et al., (1999); Sopandie et al., (2003) stated that the character of rice was decreased in low light conditions both sensitive and tolerant varieties, however, the tolerant varieties, the decrease is relatively lower. Nasution, (2009) stated that the one row spacing of corn plants have chlorophyll content of 49.51 unit.mm³ which is higher compared to the two rows spacing of 48.95 unit.mm³, an increased in the chlorophyll content of corn plants by 1.14% in the one-row spacing compared to the two-rows spacing.

The results showed that the fresh weight stover.clump⁻¹ of lowland rice varieties the highest in integrated with mature-4 of smallholder oil palm was found in the Inpari Sidenuk (V₄) variety and was not significantly different of the other varieties. The plant spacing of J₂- J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can significantly increased the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. The plant spacing of J₂-J₄ is the plant spacing were wider compared to J₁. The extent of plant spacing used will have an impact on the ability of rice plants to absorb light, nutrients, and water. According to Barri,(2003), the plant spacing system affects the light, wind, and nutrients obtained by plants which in turn gives a different effect on plant growth and yield parameters. Pedersen and Lauer, (2003) stated that the soybean yield was increased by 4% with increasing row spacing from 19 cm to 76 cm in the first year.

The results showed that the dry weight stover.clump⁻¹ of lowland rice varieties in integrated with mature-4 of smallholder oil palm the highest was found in the Inpari 10 variety (V₃) of 3.95 g and was not significant compared to other varieties. The plant spacing of 25 cm x 25 cm (J₂) gives effect the dry weight stover.clump⁻¹ the highest of 3.78 g and was not significant compared to other plant spacing.

Yield Components

The results of the ANOVA stated that the lowland rice varieties in integrated with mature-4 of smallholder oil palm can significantly increase grain yield.plot⁻¹ and yield.ha⁻¹. Plant spacing can significantly increase the lowland rice yield components except for the number of productive tillers, while their interaction had not significantly affect on yield components (Table 3).

The results were indicated that the Inpari Sidenuk variety can increase the highest grain yield.plot⁻¹ and yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively and was significantly different from other varieties. While the other yield components were not significantly different between the varieties tested. This is caused the highest leaf area found in the Inpari Sidenuk variety of 26.27 cm² compared to the others (Table 1). The extent of the leaves will affect the amount of chlorophyll in forming photosynthates and increased lowland rice grain yield. According to Johnston and Onwueme, (1998) stated that the plants will adaption to the stress of low light intensity by increasing the efficiency of light capture through increasing the amount of chlorophyll per unit leaf area. The increasing rate of photosynthesis the higher carbohydrates are formed. The carbohydrates that are available in large quantities will increase chlorophyll synthesis will result that chlorophyll rate is higher in shaded leaves.

The results were indicated that the highest percentage of empty grain was found in the plant spacing of 25 cm x 20 cm amounted to 29.61%. The plant spacing of 25 cm x 25 cm (J₂) can significantly increase the panicle length, number of grains.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. This causes the plant spacing of 25 cm x 25 cm (J₂) contributing to the highest increase in the physiological character (fresh weight stover.clump⁻¹) of lowland rice plants compared to other plant spacing (Table 2). The effect of plant spacing on the physiological response will have an impact on the yield component of lowland rice yield in integrated with mature-4 of

smallholder oil palm. Rice plants are shaded stress or low light intensity will experience changes in morphological, anatomical, physiological, and biochemical characters that will have an impact on crop production. According to Vogelmann and Martin, (1993) the light intensity will affect the shape and anatomy of leaves including epidermal and mesophyll cell types. Taiz and Zeiger, (2002) stated that the shaded leaves of plants will be thinner and wider compared to leaves of plants in normal light intensity, which is caused by the reduction in the palisade layer and mesophyll cells. Hale and Orchutt, (1987); Okada et al., (1992) stated that the physiological response of plants to shaded-stress, namely increasing the number of chloroplasts per leaf area and increasing the amount of chlorophyll in chloroplasts. Maxwell et al., (1999) stated that the low light intensity will affect chloroplasts in plants, namely an increase in the number of chloroplasts per cell, the volume of chloroplasts and thylakoid membranes, and stack granum as in *Gusmania monostachia*. Bruggeman and Danborn, (1993) stated that the shade was caused by the low activity of Rubisco whereas functions to bind CO₂ and Ribulose biphosphate (RuBP) in the Calvin cycle which produces 3-PGA. Sopandie, (2013) stated that the low light intensity during flowering in rice caused a decrease in carbohydrate, protein, auxin, proline, and cytokinin content, however, it increased the gibberellins and dissolved N content in panicles. Thorne and Koller, (1974) stated that the reduction of photosynthate at low light intensity can be related to the high resistance of stomata and mesophyll cells to CO₂ exchange. In low light conditions were decreased the carboxylase and RuBP activity.

CONCLUSION

Inpari Sidenuk variety can increase grain yield.plot⁻¹ and yield.ha⁻¹ the highest of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can increase the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm (J₂) can

increase the panicle length, number of grain.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The interaction of lowland rice varieties with plant spacing was not significantly the vegetative, physiological, and yield components in integrated with mature-4 of smallholder oil palm. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm can be used in integrated with mature-4 of smallholder oil palm in support of increased yield.ha⁻¹ and food self-sufficiency.

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TABLES

Table 1. Vegetative components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Treatment	Plant Height (cm)		Number of Tillers		Leaf Area (cm ²)
	4 WAP	6 WAP	4 WAP	6 WAP	
Varieties (V)					
V ₁ = Inpara 2	61.08	83.37	6.28	10.00	24.40
V ₂ = Inpari 4	66.73	84.31	7.15	12.23	22.90
V ₃ = Inpari 10	68.53	85.55	6.85	12.00	25.41
V ₄ = Inpari Sidenuk	70.85	90.36	6.81	11.60	26.27
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	66.28	84.38	6.41	11.05	23.04
J ₂ = (25 cm × 25 cm)	67.12	86.64	6.68	11.06	36.04
J ₃ = (25 cm × 30 cm)	64.91	85.30	7.18	11.64	20.09
J ₄ = (25 cm × 35 cm)	68.90	87.26	6.83	12.08	19.81

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 2. Physiological component of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Perlakuan	Chlorophyll (mg.cm ²)			Fresh weight stover.clump ⁻¹ (g)	Dry weight stover.clump ⁻¹ (g)
	a	b	Total		
Varieties (V)					
V ₁ = Inpara 2	3.25	4.52	7.77	12.70	3.30
V ₂ = Inpari 4	3.57	4.54	8.11	12.44	3.45
V ₃ = Inpari 10	3.53	4.17	7.70	12.18	3.95
V ₄ = Inpari Sidenuk	3.48	4.16	7.64	13.51	3.55
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	3.32	4.00	7.32	10.80 b	3.08
J ₂ = (25 cm × 25 cm)	3.35	4.37	7.72	13.53 a	3.78
J ₃ = (25 cm × 30 cm)	3.57	4.44	8.00	13.29 a	3.73
J ₄ = (25 cm × 35 cm)	3.59	4.59	8.18	13.22 a	3.66

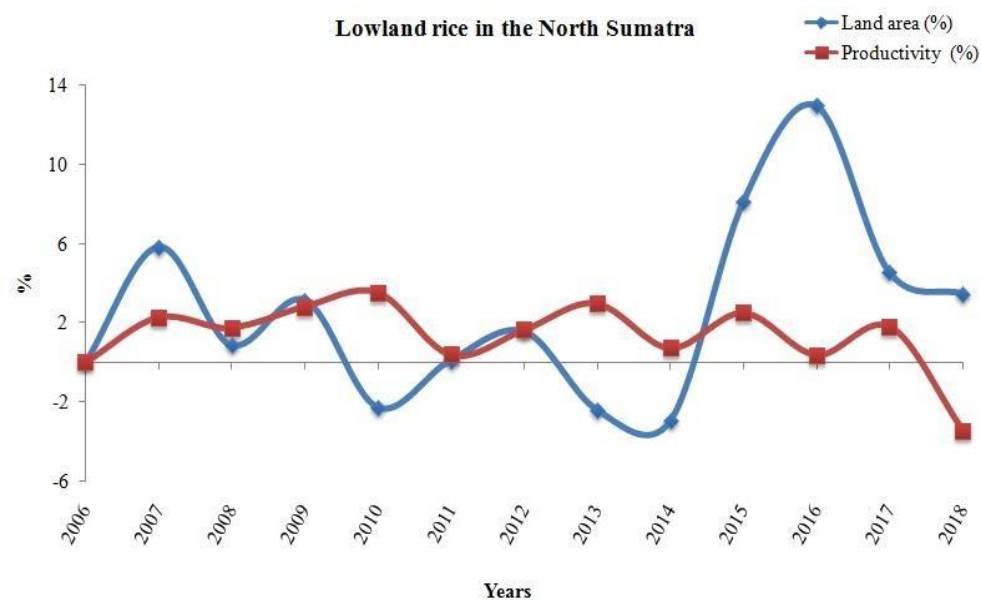
Note: The means followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 3. Yield components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Parameters	Treatment			
	V ₁ Inpara 2	V ₂ Inpari 4	V ₃ Inpari 10	V ₄ Inpari Sidenuk
Number of productive tillers	8.00	7.24	8.41	10.05
Panicle length (cm)	21.98	22.34	22.83	22.46
number of grain.panicle ⁻¹	118.70	122.05	134.38	140.27
Filled grain (%)	72.52	77.81	87.39	87.25
Empty grain (%)	32.05	27.97	9.76	8.08
1000 grains weight (g)	20.66	22.20	24.04	24.89
Grain yield.plot ⁻¹ (kg)	0.11 d	0.10 c	0.38 b	0.42 a
Yield.ha ⁻¹ (ton)	0.85 c	0.83 c	3.02 b	3.36 a

	J ₁ (25 × 20 cm)	J ₂ (25 × 25 cm)	J ₃ (25 × 30 cm)	J ₄ (25 × 35 cm)
Number of productive tillers	6.80	10.28	9.00	7.61
Panicle length (cm)	19.88 d	24.68 a	23.09 b	21.97 c
number of grain,panicle ⁻¹	108.35 d	145.00 a	137.40 b	124.65 c
Filled grain (%)	72.09 d	89.76 a	85.05 b	78.07 c
Empty grain (%)	29.62 a	17.56 b	16.04 c	14.64 d
1000 grains weight (g)	19.77 c	25.31 a	23.54 b	23.18 b
Grain yield,plot ⁻¹ (kg)	0.22 d	0.31a	0.25 b	0.23 c
Yield.ha ⁻¹ (ton)	1.76 d	2.50 a	2.00 b	1.81 c

Note: The means followed by the same letter are not significantly different at the 5% level byDuncan's Multiple Range Test.



FIGURE

Figure 1. The condition of land area and productivity of rice in the North Sumatra Province in2006 until 2018 (Source: BPS Sumatera Utara, 2019).

[aa] Editor Decision

Evaluation Report

Final Decision: Reconsider for Evaluation after Modifications and Clarifications

Article No.: 103764-AJPS-ANSI Article

Type: Research article Table Available: 3

Tables cited: 3

Figures Available: 1 Figures cited: 1

Manuscript falls in the scope of the journal? Yes

My observations/comments about this article are:

No.	Part	Comments	Author Response
1.	Cover letter	Overall OK	
2.	Write up	Overall OK	
3.	Title	provide more comprehensive and effective title within 15-17 words. While rewriting comprehensive title do not use redundant phrases (A study of, The Effect of, A review of) and repetition of preposition in it.	
4.	Running Title	Running title of the study is missing. Provide a running title of 5-7 words besides the main title in manuscript and it must be the punch line of main title	

5.	Author's Information	Clarify properly conflict of interest if any.	
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6.	Author's Contribution	Overall OK	
7.	Abstract	- Briefly describe the context of the study under the subheading of Background and Objective. - Summarize the results into 4-5 lines. Do not add unnecessary data. - Nothing is concluded, insert the concluding remarks under the subheading "Conclusion"	
8.	Keywords	Author must provide at least 7 key words. Which must be unique.	
9.	Introduction	Overall OK	
10.	Materials and Methods	Overall OK	
11.	Results	Overall OK	
12.	Figures	Overall OK	
13.	Tables	Provide each and every abbreviation and unit in the footnote of all the Tables respectively.	
14.	Discussion	Overall OK	
15.	Conclusion	Overall OK	

16.	Acknowledgement	-	
17.	Significance Statement	Please write the Significance statement as follows: "This study discovered the that can be beneficial for ---- and last sentence of this statement could be as: this study will help the researchers to uncover the critical areas of ---- that many researchers were not able to explore. Thus a new theory on ----- may be arrived at"	
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Incorporate all the recommended modifications

Vegetative, Physiological, And Yield Components Of Rice Varieties On Specific Plant Spacing In Integrated With Mature-4 Of Smallholder Oil Palm

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Hamidah Hanum Email: -	Improve of the Introduction and Results

Running title:

Conflict of interest:

ABSTRACT

Background and Objective: The research was aimed to obtain the vegetative, physiological, and yield components of several varieties of lowland rice with specific plant spacing in integrated with mature-4 of smallholder oil palm.

Materials and Method: This research used the split-plot design with the main-plot is the plant spacing ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plots is the rice varieties ($V_1 = \text{Inpara 2}$; $V_2 = \text{Inpari 4}$; $V_3 = \text{Inpari 10}$; and $V_4 = \text{Inpari Sidenuk}$). Parameters were analyzed by ANOVA and the means effect was followed by DMRT 5%.

Results: The results were showed that the Inpari Sidenuk variety significantly increased the grain yield.plot⁻¹ and the highest yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of 25 cm x 25 cm (J_2), 25 cm x 30 cm (J_3), and 25 cm x 35 cm (J_4) can significantly increase the fresh weight stover.clump⁻¹ of 13.53 g; 13.29 g; and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm can increase the panicle length, number of grain.panicle⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm has the potential to be recommended in integrated with mature-4 of smallholder oil palm to increasing yield and food self-sufficiency.

Conclusion:

Keywords: Integration, plant spacing, rice varieties, smallholder oil palm.

INTRODUCTION

The lowland rice yield in Indonesia over the past 5 years (2014-2018) has fluctuated (BPS Indonesia, 2019). One of the provinces in Indonesia as a contributor to rice yield is North Sumatra Province, however, the lowland yield is classified as fluctuated from 2006- 2018 (Figure 1). The lowland rice yield fluctuated can be caused by the rice area also has fluctuations (BPS Sumatera Utara, 2019). The decrease in the area of lowland rice harvesting can be caused by the conversion of lowland rice to oil palm plantations. The conversion of lowland rice to plantation plants such as oil palm and rubber. According to Anggari et al., (2016) the cause of the public (a case study of Trumon Subdistrict, South Aceh District) executes the conversion of lowland rice into oil palm plantations such as the risk in lowland rice farming is higher, and economic factors are more profitable. Fauzi, (2005) stated that the lowland rice conversion is the lack of certainty in the price of lowland rice so that the income from rice is lower compared to oil palm and rubber plantation.

The decrease in the lowland rice land will have an impact on the deficit of rice stocks in Indonesia. Rice demand in 2025 is expected to increase by 60%. In supply to food demand then the government through the ministry of agriculture has been focusing on seven major commodities in the program to achieve self-sufficiency and increased yield at the 2017 year through the program UPSUS PAJALE and plans to form 1 million hectares of lowland rice land until 2019 year (Nuryati et al., 2015).

The effort to form 1 million hectares of lowland rice need to be supported by the use mature of oil palm plantations through the program integration of lowland rice with oil palm plants. The application of lowland rice as intercropping among oil palm has been reviewed by previous researchers without harming the plantations. Bratkovich et al., (1993) stated that the oil palm can survive in flooded up to 3 months. Colmer and Voisenek, (2009); Dewi, (2009) reported that the oil palm is classified as very tolerant of flooded. Holidi et al., (2015) stated that the oil palm can survive in inundation conditions up to 50 days. The results showed that oil

palm in flooded conditions is very beneficial for the growth and development of lowland rice with ± 3 months to harvest.

Therefore the existence of previous research, it is expected that lowland rice plants will also be able to grow and produce until harvesting even though some shaded by oil palm canopy. However, lowland rice in the conditions of shaded will experience disruption of physiological and biochemical processes. Chozin et al., (1999) stated that one of the inhibitors to the growth and production of upland rice in intercropping is the occurrence of light deficits reaching the rice canopy. Low light intensity results in disruption of the rate of photosynthesis and carbohydrate synthesis and results in a decrease in the rate of growth and yield of plants.

Therefore several alternatives are needed to increase the yield of lowland rice with the integration of oil palms including the use of shade-tolerant varieties and plant spacing. It is very difficult to find publications and references of research results with the planting system of lowland rice in the oil palm plants. According to Murty dan Sahu, (1987); Cabuslay et al., (1991); Lubis et al., (1993) planting upland rice in the immature of oil palm area as land use can reduce yield by up to 70 until 90% in shade conditions $> 50\%$ compared to normal light. Warjido et al., (1990) stated that the plant spacing is important in optimizing the use of sunlight for photosynthesis, with the result that plants will have balanced growing space. Magfiroh et al., (2017) stated that the plant spacing of 25 cm x 25 cm can significantly increase panicle length and the number of grain.panicle⁻¹ of lowland rice of 3.60% and 8.71%, respectively compared to plant spacing of 20 cm x 20 cm.

The selection of lowland rice varieties has an important role in determining optimal yield in shaded conditions. Some varieties that can be recommended in the cultivation of lowland rice released by the Ministry of Agriculture include Inpara 2, Inpari Sidenuk, Inpari 10, and Inpari 4 with an average yield of 5.49; 6.60; 6.00; and 6.04 tons.ha⁻¹, respectively. Therefore further research is needed on the use of several varieties of lowland rice that can

yield in oil palm to support national food security. The purpose of this research was to obtain high-yielding lowland rice varieties at plant spacing with integrated mature-4 of smallholder oil palm.

MATERIAL AND METHODS

Land Management

The research integration of lowland rice and mature-4 of oil palm oil with the number population of 72 trees (0.50 ha) which is located at Titi Payung street, Hamparan Perak Subdistrict, Deli Serdang District, North Sumatra Province, Indonesia in April until August 2017. This research conducted with the processing of the land using the hand tractor. The soil was cultivated three folds as deep as 20 cm, using the rotary plow.

Plot Size and Research Design

The plot was made with a size of 10 m x 20 m. This research used the split plot design with the main-plot is the plant spacing of 4 levels ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plot is lowland rice varieties consisting of 4 varieties, namely ($V_1 = \text{Inpara 2}$; ($V_2 = \text{Inpari 4}$; ($V_3 = \text{Inpari 10}$; and ($V_4 = \text{Inpari Sidenuk}$). The treatment of this research was used the three replications.

Seeding and Planting Process

Seed rice was soaked in water for 24 hours and then drained for 12 hours. The seeds that have germinated are then sown in the nursery and after 2 weeks were moved to the plot. After the seedlings are 3 weeks and planting was conducted in the plot following the treatment in manually, each hole only one plant. The number of plants in the sub-plot was 24 plants with 5 plant samples.

Plant Management

The transfer of seedlings, water has flowed into the plot with a height of 5 cm until the plant is 45 days old. The insertion was performed during 2 weeks after planting (WAP) or before the basic fertilization. Weeding was conducted in the initial period until 21 and 42 WAP used the manually when weeds have 3-4 leaves, then flooded for 1 day. Fertilization was conducted with N 90 kg.ha⁻¹, TSP 50 kg.ha⁻¹, and KCl 50 kg.ha⁻¹. The phosphorus and potassium fertilizer are given as basic fertilizers and given before transplanting seedlings, while N fertilizer is

given 3 folds such as a week after transplanting, 40 days after transplanting and 65-70 days old. Pest and disease control is only conducted when the symptoms of an attack have reached the economic threshold using insecticides, and fungicides that are adjusted to pests/diseases.

Harvesting

Two weeks before harvesting the lowland rice water is drained so that the rice grains mature quickly. Harvesting was conducted manually using the sickle at the mature plant physiology marked visually in lowland rice, such as rice grains were yellowed ranged from 90 until 95% or grain moisture content ranges from 22 until 27%.

Parameters and

Analysis Data

Vegetative

Components

The parameters of the vegetative components such as plant height (cm), number of tillers, and leaf area (cm²). Plant height and number of tillers were measured at 4 and 6 WAP. Leaf area was measured at harvest by taking a flag leaf from each sample and calculated by the formula $p \times l \times 0.75$.

Physiological Components

The parameters of the physiological component such as leaf chlorophyll content (chlorophyll a, b, and total), fresh weight stover.clump⁻¹ (g), and dry weight stover.clump⁻¹ (g). The chlorophyll a, b, and total were measured using the UV-Vis spectrophotometer (Hendry and Grime, 1993). The extraction of chlorophyll was conducted with acetone 80%, the leaves are weighed 0.1 g, then crushed in the mortal, inserted 10 ml acetone, filtered with Whatman filter paper. The filtrate was measured for absorbance at 645 nm and 663 nm. The calculation of chlorophyll a, b and total content using the formula:

$$\text{Chlorophyll a} = (12.7 \times A_{663} - 2.69 \times A_{645}) \times 10^{-1} \quad (1)$$

$$\text{Chlorophyll b} = (22.9 \times A_{645} - 4.68 \times A_{663}) \times 10^{-1} \quad (2)$$

$$\text{Chlorophyll total} = (8.02 \times A_{663} + 20.2 \times A_{645}) \times 10^{-1} \quad (3)$$

Fresh weight stover.clump⁻¹ was cut from the base of the stem at the end of the research, be weighed, then put into a brown envelope and dried in the sun for 3 days and oven at 60°C for 72 hours to obtain the dry weight stover.clump⁻¹ after which it was weighed using analytical scales.

Yield Component

The parameters of the yield component such as the number of productive tillers, panicle length (cm), number of grain.panicle⁻¹, filled grain (%), empty grain (%), 1000 grains weight (g), grain yield.plot⁻¹ (kg), and yield.ha⁻¹ (tons). The number of productive tillers was measured when the plants were flowered, by counting the tillers produce panicles. Panicle length was measured when the plant has been harvested by measuring the panicle formed.clump⁻¹ from the base to the end of the panicle. The number of grains.panicle⁻¹ was calculated by dividing the total number of grains in the sample with the total number of panicles. The percentage of filled grains was calculated by dividing the number of filled grains from all panicles of the sample with the total number of grains. The percentage of empty grains was calculated by dividing the number of empty grains from all panicles of the sample with the total number of grains. The 1000 grains weight was measured by drying up to moisture content of 14% and take by 1000 rice grains randomly then weighed. The grain yield.plot⁻¹ was calculated by weighing the filled grain in each plot and weighed using analytical scales. The yield.ha⁻¹ was calculated by converting the average grain yield.plot⁻¹ using the formula:

$$\text{Yield/ha}^{-1} = \frac{\text{Average Yield.Plot}^{-1}}{\text{Plot Area}} \times \text{Area of 1 ha} \quad (4)$$

Parameters were analyzed with analysis of variance (ANOVA) and the significant effect was followed by Duncan's Multiple Range Test (DMRT) at the level of 5%.

RESULTS AND DISCUSSION

Vegetative Components

The results of the ANOVA showed that the varieties, plant spacing and their interaction not significantly influence the increase in plant height, number of tillers and leaf area of lowland rice in integrated with mature-4 of smallholder oil palm (Table 1).

The results showed that the plant height of lowland rice varieties was integrated with mature-4 of smallholder oil palm highest were found in the Inpari Sidenuk variety (V_4) of 70.85 cm and 90.36 cm, respectively at 4 and 6 WAP. The plant spacing of 25 cm x 35 cm (J_4) is the spacing that the highest of plant height amounted to 68.90 cm and 87.26 cm, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in Inpari 4 variety (V_2) of 7.15 tillers and 12.23 tillers, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm $\times$ 30 cm (J_3) of 7.18 tillers at 4 WAP, and found in 25 cm $\times$ 35 cm (J_4) of 12.08 tillers at 6 WAP. The leaf area of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the Inpari Sidenuk variety (V_4) of 26.27 cm², and plant spacing of 25 cm x 25 cm (J_2) amounted to 38.97 cm².

Rice variety of Inpari Sidenuk (V_4) and plant spacing of 25 cm x 25 cm (J_2) in integration with mature-4 of smallholder oil palm can adapt to the low light intensity, this is evidenced by the highest leaf area compared to the others treatment. According to Levitt, (1980) an adaptation of plants to shade can be conducted through avoidance that is associated with response to changes in the anatomy and morphology of leaves for photosynthesis efficient. The efficiency of increasing light capture can be conducted by increasing the area of light capture, by increasing the leaf area. Yeo, (1994); Santosa et al., (2000); Sopandie et al., (2006) stated that the low light in upland rice cause disturbed metabolic processes which have implications for decreasing the rate of photosynthesis and carbohydrate synthesis.

Physiological Components

The results of the ANOVA showed that planting spacing significantly increased the fresh weight stover.clump⁻¹, however not significantly increased the chlorophyll a, b, total, and dry weight stover.clump⁻¹ of lowland rice. Varieties and their interactions not significant effect in increasing the physiological component of lowland rice in integrated with mature-4 of smallholder oil palm (Table 2).

The results showed that the Inpari 4 variety had higher levels of chlorophyll a, b, and total of 3.57 mg.cm², 4.54 mg.cm², and 8.11 mg.cm², respectively compared to other varieties. The chlorophyll a, b, and total of lowland rice varieties were integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 35 cm (J₄) of 3.59 mg.cm², 4.59 mg.cm², and 8.18 mg.cm², respectively compared to other plant spacing. Lowland rice varieties are very tolerant of shading were showed that the change in morphological character (leaf area) as lower compared to sensitive varieties. The effect of plant spacing of 25 cm × 35 cm (J₄) has an impact on the amount of light that can be absorbed by lowland rice because the spacing between plants is relatively wider compared to other plant spacing. Chozin et al., (1999); Sopandie et al., (2003) stated that the character of rice was decreased in low light conditions both sensitive and tolerant varieties, however, the tolerant varieties, the decrease is relatively lower. Nasution, (2009) stated that the one row spacing of corn plants have chlorophyll content of 49.51 unit.mm³ which is higher compared to the two rows spacing of 48.95 unit.mm³, an increased in the chlorophyll content of corn plants by 1.14% in the one-row spacing compared to the two-rows spacing.

The results showed that the fresh weight stover.clump⁻¹ of lowland rice varieties the highest in integrated with mature-4 of smallholder oil palm was found in the Inpari Sidenuk (V₄) variety and was not significantly different of the other varieties. The plant spacing of J₂- J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can significantly increased the fresh

weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. The plant spacing of J₂-J₄ is the plant spacing were wider compared to J₁. The extent of plant spacing used will have an impact on the ability of rice plants to absorb light, nutrients, and water. According to Barri, (2003), the plant spacing system affects the light, wind, and nutrients obtained by plants which in turn gives a different effect on plant growth and yield parameters. Pedersen and Lauer, (2003) stated that the soybean yield was increased by 4% with increasing row spacing from 19 cm to 76 cm in the first year.

The results showed that the dry weight stover.clump⁻¹ of lowland rice varieties in integrated with mature-4 of smallholder oil palm the highest was found in the Inpari 10 variety (V₃) of 3.95 g and was not significant compared to other varieties. The plant spacing of 25 cm x 25 cm (J₂) gives effect the dry weight stover.clump⁻¹ the highest of 3.78 g and was not significant compared to other plant spacing.

Yield Components

The results of the ANOVA stated that the lowland rice varieties in integrated with mature-4 of smallholder oil palm can significantly increase grain yield.plot⁻¹ and yield.ha⁻¹. Plant spacing can significantly increase the lowland rice yield components except for the number of productive tillers, while their interaction had not significantly affect on yield components (Table 3).

The results were indicated that the Inpari Sidenuk variety can increase the highest grain yield.plot⁻¹ and yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively and was significantly different from other varieties. While the other yield components were not significantly different between the varieties tested. This is caused the highest leaf area found in the Inpari Sidenuk variety of 26.27 cm² compared to the others (Table 1). The extent of the leaves will affect the amount of chlorophyll in forming photosynthates and increased lowland rice grain

yield. According to Johnston and Onwueme, (1998) stated that the plants will adapt to the stress of low light intensity by increasing the efficiency of light capture through increasing the amount of chlorophyll per unit leaf area. The increasing rate of photosynthesis the higher carbohydrates are formed. The carbohydrates that are available in large quantities will increase chlorophyll synthesis will result that chlorophyll rate is higher in shaded leaves.

The results were indicated that the highest percentage of empty grain was found in the plant spacing of 25 cm x 20 cm amounted to 29.61%. The plant spacing of 25 cm x 25 cm (J_2) can significantly increase the panicle length, number of grains.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. This causes the plant spacing of 25 cm x 25 cm (J_2) contributing to the highest increase in the physiological character (fresh weight stover.clump⁻¹) of lowland rice plants compared to other plant spacing (Table 2). The effect of plant spacing on the physiological response will have an impact on the yield component of lowland rice yield in integrated with mature-4 of smallholder oil palm. Rice plants are shaded stress or low light intensity will experience changes in morphological, anatomical, physiological, and biochemical characters that will have an impact on crop production. According to Vogelmann and Martin, (1993) the light intensity will affect the shape and anatomy of leaves including epidermal and mesophyll cell types. Taiz and Zeiger, (2002) stated that the shaded leaves of plants will be thinner and wider compared to leaves of plants in normal light intensity, which is caused by the reduction in the palisade layer and mesophyll cells. Hale and Orchutt, (1987); Okada et al., (1992) stated that the physiological response of plants to shaded-stress, namely increasing the number of chloroplasts per leaf area and increasing the amount of chlorophyll in chloroplasts. Maxwell et al., (1999) stated that the low light intensity will affect chloroplasts in plants, namely an increase in the number of chloroplasts per cell, the volume of chloroplasts and thylakoid membranes, and stack granum as in *Gusmania monostachia*. Bruggeman and Danborn, (1993)

stated that the shade was caused by the low activity of Rubisco whereas functions to bind CO₂ and Ribulose biphosphate (RuBP) in the Calvin cycle which produces 3-PGA. Sopandie, (2013) stated that the low light intensity during flowering in rice caused a decrease in carbohydrate, protein, auxin, proline, and cytokinin content, however, it increased the gibberellins and dissolved N content in panicles. Thorne and Koller, (1974) stated that the reduction of photosynthate at low light intensity can be related to the high resistance of stomata and mesophyll cells to CO₂ exchange. In low light conditions were decreased the carboxylase and RuBP activity.

CONCLUSION

Inpari Sidenuk variety can increase grain yield.plot⁻¹ and yield.ha⁻¹ the highest of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can increase the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm (J₂) can increase the panicle length, number of grain.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The interaction of lowland rice varieties with plant spacing was not significantly the vegetative, physiological, and yield components in integrated with mature-4 of smallholder oil palm. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm can be used in integrated with mature-4 of smallholder oil palm in support of increased yield.ha⁻¹ and food self-sufficiency.

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SIGNIFICANCE STATEMENT

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TABLES

Table 1. Vegetative components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Treatment	Plant Height (cm)		Number of Tillers		Leaf Area (cm ²)
	4 WAP	6 WAP	4 WAP	6 WAP	
Varieties (V)					
V ₁ = Inpara 2	61.08	83.37	6.28	10.00	24.40
V ₂ = Inpari 4	66.73	84.31	7.15	12.23	22.90
V ₃ = Inpari 10	68.53	85.55	6.85	12.00	25.41
V ₄ = Inpari Sidenuk	70.85	90.36	6.81	11.60	26.27
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	66.28	84.38	6.41	11.05	23.04
J ₂ = (25 cm × 25 cm)	67.12	86.64	6.68	11.06	36.04
J ₃ = (25 cm × 30 cm)	64.91	85.30	7.18	11.64	20.09
J ₄ = (25 cm × 35 cm)	68.90	87.26	6.83	12.08	19.81

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 2. Physiological component of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Perlakuan	Chlorophyll (mg.cm ²)			Fresh weight stover.clump ⁻¹ (g)	Dry weight stover.clump ⁻¹ (g)
	a	b	Total		
Varieties (V)					
V ₁ = Inpara 2	3.25	4.52	7.77	12.70	3.30
V ₂ = Inpari 4	3.57	4.54	8.11	12.44	3.45
V ₃ = Inpari 10	3.53	4.17	7.70	12.18	3.95
V ₄ = Inpari Sidenuk	3.48	4.16	7.64	13.51	3.55
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	3.32	4.00	7.32	10.80 b	3.08
J ₂ = (25 cm × 25 cm)	3.35	4.37	7.72	13.53 a	3.78
J ₃ = (25 cm × 30 cm)	3.57	4.44	8.00	13.29 a	3.73
J ₄ = (25 cm × 35 cm)	3.59	4.59	8.18	13.22 a	3.66

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 3. Yield components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Parameters	Treatment			
	V ₁ Inpara 2	V ₂ Inpari 4	V ₃ Inpari 10	V ₄ Inpari Sidenuk
Number of productive tillers	8.00	7.24	8.41	10.05
Panicle length (cm)	21.98	22.34	22.83	22.46
number of grain.panicle ⁻¹	118.70	122.05	134.38	140.27
Filled grain (%)	72.52	77.81	87.39	87.25
Empty grain (%)	32.05	27.97	9.76	8.08
1000 grains weight (g)	20.66	22.20	24.04	24.89
Grain yield.plot ⁻¹ (kg)	0.11 d	0.10 c	0.38 b	0.42 a
Yield.ha ⁻¹ (ton)	0.85 c	0.83 c	3.02 b	3.36 a
	J ₁ (25 × 20 cm)	J ₂ (25 × 25 cm)	J ₃ (25 × 30 cm)	J ₄ (25 × 35 cm)
Number of productive tillers	6.80	10.28	9.00	7.61
Panicle length (cm)	19.88 d	24.68 a	23.09 b	21.97 c
number of grain.panicle ⁻¹	108.35 d	145.00 a	137.40 b	124.65 c
Filled grain (%)	72.09 d	89.76 a	85.05 b	78.07 c
Empty grain (%)	29.62 a	17.56 b	16.04 c	14.64 d
1000 grains weight (g)	19.77 c	25.31 a	23.54 b	23.18 b
Grain yield.plot ⁻¹ (kg)	0.22 d	0.31a	0.25 b	0.23 c
Yield.ha ⁻¹ (ton)	1.76 d	2.50 a	2.00 b	1.81 c

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

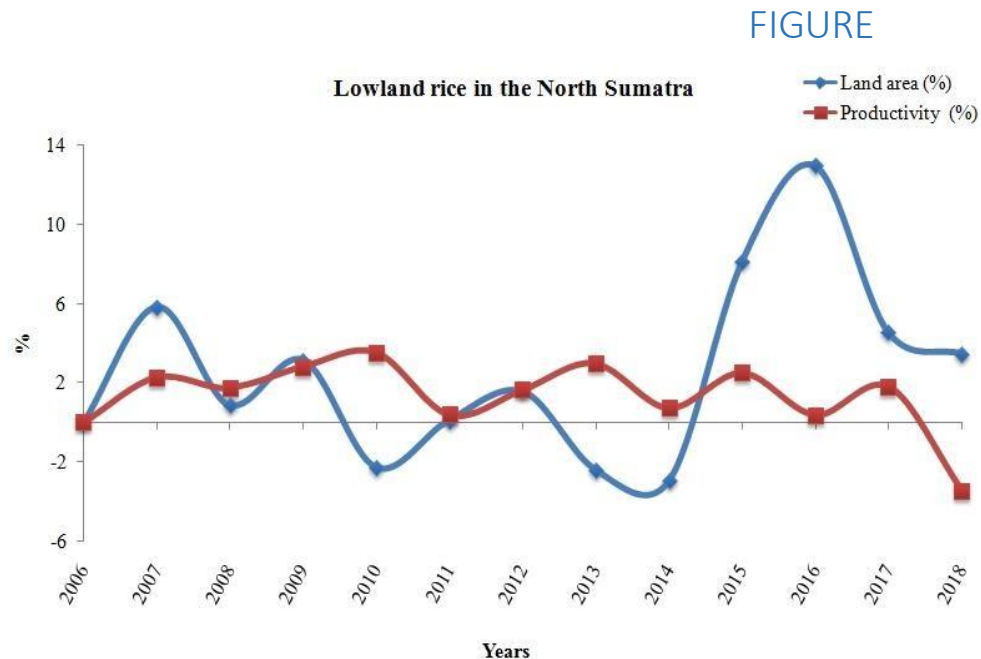


Figure 1. The condition of land area and productivity of rice in the North Sumatra Province in 2006 until 2018 (Source: BPS Sumatera Utara, 2019).

Revisi 1

Evaluation Report

Final Decision: Reconsider for Evaluation after Modifications and Clarifications

Article No.:103764-AJPS-ANSI Article Type:

Research article Table Available: 3 Tables cited: 3

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Manuscript falls in the scope of the journal? Yes

My observations/comments about this article are:

No.	Part	Comments	Author Response
1.	Cover letter	Overall OK	Thank you

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3.	Title	Title does not make any sense. Keep in mind that Title is the main part of the study which attracts the reader's attention. Therefore, rewrite the Title.	The title was changed according to your suggestion.
4.	Running Title	Overall OK	
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8.	Keywords	• Author didn't incorpoate the following chnages. • Author must provide at least 7 key words. Which must be unique.	The keywords was changed according to your suggestion.
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14.	Discussion	• Overall OK	Thank you
15.	Conclusion	• Overall OK	Thank you
16.	Acknowledgement	• -	-
17.	Significance Statement	• Overall OK	The significance statement was changed.
18.	References	• Author is requested to complete all the incomplete sentences used throughout the manuscript. For example: • ⁴has reported that 75 – 90% of world rural	The references was changed according to Asian Journal of Plant Science format.

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Vegetative, Physiological and Yield of Rice Varieties on Plant

Spacing in Integrated Mature-4 of Smallholder

Oil Palm

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Hamidah Hanum Email: -	Improve of the Introduction and Results

Running title: Integrated of Lowland Rice in Oil Palm

Conflict of interest: The authors have declared no conflict of interest

ABSTRACT

Background and Objective: The effort of lowland rice need to be supported by the program integration of lowland rice with oil palm plants to food self-sufficiency. The research was aimed to obtain the vegetative, physiological, and yield components of several varieties of lowland rice with specific plant spacing in integrated mature-4 of smallholder oil palm.

Material and Methods: The research used the split-plot design with the main-plot is the plant spacing ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plots is the rice varieties ($V_1 = \text{Inpara 2}$; $V_2 = \text{Inpari 4}$; $V_3 = \text{Inpari 10}$; and $V_4 = \text{Inpari Sidenuk}$). Parameters were analyzed by ANOVA and the means effect was followed by DMRT at level of 5%.

Results: The results showed that the Inpari Sidenuk variety significantly increased the grain yield.plot⁻¹ and the highest yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of 25 cm x 25 cm (J_2), 25 cm x 30 cm (J_3), and 25 cm x 35 cm (J_4) can significantly increase the fresh weight stover.clump⁻¹ of 13.53 g; 13.29 g; and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm can increase the panicle length, number of grain.panicle⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing.

Conclusion: The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm has the potential to be recommended in integrated with mature-4 of smallholder oil palm to increasing yield and food self-sufficiency.

Keywords: Integration, plant spacing, rice varieties, smallholder oil palm.

INTRODUCTION

The lowland rice yield in Indonesia over the past 5 years (2014-2018) has fluctuated¹. One of the provinces in Indonesia as a contributor to rice yield is North Sumatra Province, however, the lowland yield is classified as fluctuated from 2006 until 2018. The lowland rice yield fluctuated can be caused by the rice area also has fluctuations². The decrease in the area of lowland rice harvesting can be caused by the conversion of lowland rice to oil palm plantations. The conversion of lowland rice to plantation plants such as oil palm and rubber.³The cause of the public executes the conversion of lowland rice into oil palm plantations such as the risk in lowland rice farming is higher, and economic factors are more profitable in Trumon sub-District, South Aceh District). ⁴stated that the lowland rice conversion is the lack of certainty in the price of lowland rice so that the income from rice is lower compared to oil palm and rubber plantation.

The decrease in the lowland rice land will have an impact on the deficit of rice stocks in Indonesia. Rice demand in 2025 is expected to increase by 60%. In supply to food demand then the government through the ministry of agriculture has been focusing on seven major commodities in the program to achieve self-sufficiency and increased yield at the 2017 year through the program “UPSUS PAJALE” and plans to form 1 million hectares of lowland rice land until 2019 year⁵.

The effort to form 1 million hectares of lowland rice need to be supported by the use mature of oil palm plantations through the program integration of lowland rice with oil palm plants. The application of lowland rice as intercropping among oil palm has been reviewed by previous researchers without harming the plantations. ⁶stated that the oil palm can survive in flooded up to 3 months. ^{7,8}reported that the oil palm is classified as very tolerant of flooded. ⁹stated that the oil palm can survive in inundation conditions up to 50 days. The results showed that oil palm in flooded conditions is very beneficial for the growth and development of lowland rice with $\pm$ 3 months to harvest.

Therefore the existence of previous research, it is expected that lowland rice plants will also be able to grow and produce until harvesting even though several shaded by oil palm canopy. However, lowland rice in the conditions of shaded will experience disruption of physiological and biochemical processes. ¹⁰stated that one of the inhibitors to the growth and production of upland rice in intercropping is the occurrence of light deficits reaching the rice canopy. Low light intensity results in disruption of the rate of photosynthesis and carbohydrate synthesis and results in a decrease in the rate of growth and yield of plants.

Therefore several alternatives are needed to increase the yield of lowland rice with the integration of oil palms including the use of shade-tolerant varieties and plant spacing. It is very difficult to find publications and references of research results with the planting system of lowland rice in the oil palm plants. According to ^{11,12,13}planting upland rice in the immature of oil palm area as land use can reduce yield by up to 70 until 90% in shade conditions > 50% compared to normal light. ¹⁴stated that the plant spacing is important in optimizing the use of sunlight for photosynthesis, with the result that plants will have balanced growing space. ¹⁵stated that the plant spacing of 25 cm x 25 cm can significantly increase panicle length and the number of grain.panicle⁻¹ of lowland rice of 3.60% and 8.71%, respectively compared to plant spacing of 20 cm x 20 cm.

. The purpose of this research was to obtain high-yielding lowland rice varieties at plant spacing with integrated mature-4 of smallholder oil palm.

MATERIAL AND METHODS

Land Management

The research integration of lowland rice and mature-4 of oil palm oil with the number population of 72 trees or 0.50 ha which is located at Titi Payung Street, Hamparan Perak sub-District, Deli Serdang District, North Sumatra Province, Indonesia in April until August 2017. This research was conducted with the processing of the land using the hand tractor. The soil was cultivated three folds as deep as 20 cm, using the rotary plow.

Plot Size and Research Design

The plot was made with a size of 10 m x 20 m. This research used the split plot design with the main-plot is the plant spacing of 4 levels ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plot is lowland rice varieties consisting of 4 varieties, namely ($V_1 = \text{Inpara 2}$; ($V_2 = \text{Inpari 4}$; ($V_3 = \text{Inpari 10}$; and ($V_4 = \text{Inpari Sidenuk}$). The treatment of this research was used the three replications.

Seeding and Planting Process

Seed rice was soaked in water for 24 hours and then drained for 12 hours. The seeds that have germinated are then sown in the nursery and after 2 weeks were moved to the plot. After the seedlings are 3 weeks and planting was conducted in the plot following the treatment in manually, each hole only one plant. The number of plants in the sub-plot was 24 plants with five plant samples.

Plant Management

The transfer of seedlings, water has flowed into the plot with the height of 5 cm until the plant is 45 days old. The insertion was performed during 2 weeks after planting (WAP) or before the basic fertilization. Weeding was conducted in the initial period until 21 and 42 WAP used the manually when weeds have 3 to 4 leaves, then flooded for 1 day. Fertilization was conducted with N 90 kg.ha⁻¹, TSP 50 kg.ha⁻¹, and KCl 50 kg.ha⁻¹. The phosphorus and

potassium fertilizer are given before transplanting seedlings, while N fertilizer is given 3 folds such as a week after transplanting, 40 days after transplanting and 65 to 70 days old. Pest and disease control is only conducted when the symptoms of an attack have reached the economic threshold using insecticides, and fungicides that are adjusted to pests/diseases.

Harvesting

Two weeks before harvesting the lowland rice water is drained so that the rice grains mature quickly. Harvesting was conducted manually using the sickle at the mature plant physiology marked visually in lowland rice, such as rice grains were yellowed ranged from 90 until 95% or grain moisture content ranges from 22 until 27%.

Parameters and Analysis

Data Vegetative

Components

The parameters of the vegetative components such as plant height (cm), number of tillers, and leaf area (cm²). Plant height and number of tillers were measured at 4 and 6 WAP. Leaf area was measured at harvest by taking a flag leaf from each sample and calculated by the formula $p \times l \times 0.75$.

Physiological Components

The parameters of the physiological component such as leaf chlorophyll content (chlorophyll a, b, and total), fresh weight stover.clump⁻¹ (g), and dry weight stover.clump⁻¹ (g). The chlorophyll a, b, and total were measured using the UV-Vis spectrophotometer¹⁶. The extraction of chlorophyll was conducted with acetone 80%, the leaves are weighed 0.1 g, then crushed in the mortal, inserted 10 ml acetone, filtered with Whatman filter paper. The filtrate was measured for absorbance at 645 nm and 663 nm. The calculation of chlorophyll a, b and total content using the formula:

$$\text{Chlorophyll a} = (12.7 \times A_{663} - 2.69 \times A_{645}) \times 10^{-1} \quad (1)$$

$$\text{Chlorophyll b} = (22.9 \times A_{645} - 4.68 \times A_{663}) \times 10^{-1} \quad (2)$$

$$\text{Chlorophyll total} = (8.02 \times A663 + 20.2 \times A645) \times 10^{-1} \quad (3)$$

Fresh weight stover.clump⁻¹ was cut from the base of the stem at the end of the research, be weighed, then put into a brown envelope and dried in the sun for 3 days and oven at 60°C for 72 hours to obtain the dry weight stover.clump⁻¹ after which it was weighed using analytical scales.

Yield Component

The parameters of the yield component such as the number of productive tillers, panicle length (cm), number of grain.panicle⁻¹, filled grain (%), empty grain (%), 1000 grains weight (g), grain yield.plot⁻¹ (kg), and yield.ha⁻¹ (tons). The number of productive tillers was measured when the plants were flowered, by counting the tillers produce panicles. Panicle length was measured when the plant has been harvested by measuring the panicle formed.clump⁻¹ from the base to the end of the panicle. The number of grains.panicle⁻¹ was calculated by dividing the total number of grains in the sample with the total number of panicles. The percentage of filled grains was calculated by dividing the number of filled grains from all panicles of the sample with the total number of grains. The percentage of empty grains was calculated by dividing the number of empty grains from all panicles of the sample with the total number of grains. The 1000 grains weight was measured by drying up to moisture content of 14% and take by 1000 rice grains randomly then weighed. The grain yield.plot⁻¹ was calculated by weighing the filled grain in each plot and weighed using analytical scales. The yield.ha⁻¹ was calculated by converting the average grain yield.plot⁻¹ using the formula:

$$\text{Yield/ha}^{-1} = \frac{\text{Average Yield.Plot}^{-1}}{\text{Plot Area}} \times \text{Area of 1 ha} \quad (4)$$

Parameters were analyzed with analysis of variance (ANOVA) and the significant effect was followed by Duncan's Multiple Range Test (DMRT) at the level of 5%.

RESULTS AND DISCUSSION

Vegetative Components

The results of the ANOVA showed that the varieties, plant spacing and their interaction not significantly influence the increase in plant height, number of tillers and leaf area of lowland rice in integrated with mature-4 of smallholder oil palm (Table 1).

Table 1. Vegetative components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Treatment	Plant Height (cm)		Number of Tillers		Leaf Area (cm ²)
	4 WAP	6 WAP	4 WAP	6 WAP	
Varieties (V)					
V ₁ = Inpara 2	61.08	83.37	6.28	10.00	24.40
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J ₃ = (25 cm × 30 cm)	64.91	85.30	7.18	11.64	20.09
J ₄ = (25 cm × 35 cm)	68.90	87.26	6.83	12.08	19.81

Note: Weeks after planting (WAP). The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test.

The results showed that the plant height of lowland rice varieties was integrated with mature-4 of smallholder oil palm highest were found in the Inpari Sidenuk variety (V₄) of 70.85 cm and 90.36 cm, respectively at 4 and 6 WAP. The plant spacing of 25 cm x 35 cm (J₄) is the spacing that the highest of plant height amounted to 68.90 cm and 87.26 cm, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in Inpari 4 variety (V₂) of 7.15 tillers and 12.23 tillers, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 30 cm (J₃) of 7.18 tillers at 4 WAP, and found in 25 cm × 35 cm (J₄) of 12.08 tillers at 6 WAP. The leaf area of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the Inpari Sidenuk variety (V₄) of 26.27 cm², and plant spacing of 25 cm x 25 cm (J₂) amounted to 38.97 cm².

Rice variety of Inpari Sidenuk (V₄) and plant spacing of 25 cm x 25 cm (J₂) in integration with mature-4 of smallholder oil palm can adapt to the low light intensity, this is evidenced by the highest leaf area compared to the others treatment. According to ¹⁷plant adaptation to shade can be conducted through avoidance that is associated with response to changes in the anatomy and morphology of leaves for photosynthesis efficient. The efficiency of increasing light capture can be conducted by increasing the area of light capture, by increasing the leaf area. ^{18,19,20}stated that the low light in upland rice cause disturbed metabolic processes which have implications for decreasing the rate of photosynthesis and carbohydrate synthesis.

Physiological Components

The results of the ANOVA showed that the plant spacing significantly increased the fresh weight stover.clump⁻¹, however not significantly increased the chlorophyll a, b, total, and dry weight stover.clump⁻¹ of lowland rice. Varieties and their interactions not significant effect in increasing the physiological component of lowland rice in integrated with mature-4 of smallholder oil palm (Table 2).

Table 2. Physiological component of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Perlakuan	Chlorophyll (mg.cm ²)			Fresh weight stover.clump ⁻¹ (g)	Dry weight stover.clump ⁻¹ (g)
	a	b	Total		
Varieties (V)					
V ₁ = Inpara 2	3.25	4.52	7.77	12.70	3.30
V ₂ = Inpari 4	3.57	4.54	8.11	12.44	3.45
V ₃ = Inpari 10	3.53	4.17	7.70	12.18	3.95
V ₄ = Inpari Sidenuk	3.48	4.16	7.64	13.51	3.55
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	3.32	4.00	7.32	10.80 b	3.08
J ₂ = (25 cm × 25 cm)	3.35	4.37	7.72	13.53 a	3.78
J ₃ = (25 cm × 30 cm)	3.57	4.44	8.00	13.29 a	3.73
J ₄ = (25 cm × 35 cm)	3.59	4.59	8.18	13.22 a	3.66

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test

The results showed that the Inpari 4 variety had higher levels of chlorophyll a, b, and total of 3.57 mg.cm², 4.54 mg.cm², and 8.11 mg.cm², respectively compared to other varieties. The chlorophyll a, b, and total of lowland rice varieties were integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 35 cm(J₄) of 3.59 mg.cm², 4.59 mg.cm², and 8.18 mg.cm², respectively compared to other plant spacing. Lowland rice varieties are very tolerant of shading were showed that the change in morphological character (leaf area) as lower compared to sensitive varieties. The effect of plant spacing of 25 cm × 35 cm (J₄) has an impact on the amount of light that can be absorbed by lowland rice because the spacing between plants is relatively wider compared to other plant spacing. ^{10,21}stated that the character of rice was decreased in low light conditions both sensitive and tolerant varieties, however, the tolerant varieties, the decrease is relatively lower. ²²stated that the one row spacing of corn plants have chlorophyll content of 49.51 unit.mm³ which is higher compared to the two rows spacing of 48.95 unit.mm³, an increased in the chlorophyll content of corn plants by 1.14% in the one-row spacing compared to the two-rows spacing.

The results showed that the fresh weight stover.clump⁻¹ of lowland rice varieties the highest in integrated with mature-4 of smallholder oil palm was found in the Inpari Sidenuk (V₄) variety and was not significantly different of the other varieties. The plant spacing of J₂- J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can significantly increased the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. The plant spacing of J₂-J₄is the plant spacing were wider compared to J₁. The extent of plant spacing used will have an impact on the ability of rice plants to absorb light, nutrients, and water. According to ²³the plant spacing system affects the light, wind, and nutrients obtained by plants which in turn gives a different effect on plant growth and yield parameters. ²⁴stated that the soybean yield was increased by 4% with increasing row spacing from 19 cm to 76 cm in the first year.

The results showed that the dry weight stover.clump⁻¹ of lowland rice varieties in integrated with mature-4 of smallholder oil palm the highest was found in the Inpari 10 variety (V₃) of 3.95 g and was not significant compared to other varieties. The plant spacing of 25 cm x 25 cm (J₂) gives effect the dry weight stover.clump⁻¹ the highest of 3.78 g and was not significant compared to other plant spacing.

Yield Components

The lowland rice varieties in integrated with mature-4 of smallholder oil palm can significantly increase grain yield.plot⁻¹ and yield.ha⁻¹. Plant spacing can significantly increase the lowland rice yield components except for the number of productive tillers, while their interaction had not significantly affect on yield components (Table 3).

Table 3. Yield components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Parameters	Treatment			
	V ₁ Inpara 2	V ₂ Inpari 4	V ₃ Inpari 10	V ₄ Inpari Sidenuk
Number of productive tillers	8.00	7.24	8.41	10.05
Panicle length (cm)	21.98	22.34	22.83	22.46
number of grain.panicle ⁻¹	118.70	122.05	134.38	140.27
Filled grain (%)	72.52	77.81	87.39	87.25
Empty grain (%)	32.05	27.97	9.76	8.08
1000 grains weight (g)	20.66	22.20	24.04	24.89
Grain yield.plot ⁻¹ (kg)	0.11 d	0.10 c	0.38 b	0.42 a
Yield.ha ⁻¹ (ton)	0.85 c	0.83 c	3.02 b	3.36 a
	J ₁ (25 × 20 cm)	J ₂ (25 × 25 cm)	J ₃ (25 × 30 cm)	J ₄ (25 × 35 cm)
Number of productive tillers	6.80	10.28	9.00	7.61
Panicle length (cm)	19.88 d	24.68 a	23.09 b	21.97 c
number of grain.panicle ⁻¹	108.35 d	145.00 a	137.40 b	124.65 c
Filled grain (%)	72.09 d	89.76 a	85.05 b	78.07 c
Empty grain (%)	29.62 a	17.56 b	16.04 c	14.64 d
1000 grains weight (g)	19.77 c	25.31 a	23.54 b	23.18 b
Grain yield.plot ⁻¹ (kg)	0.22 d	0.31a	0.25 b	0.23 c
Yield.ha ⁻¹ (ton)	1.76 d	2.50 a	2.00 b	1.81 c

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test

The results were indicated that the Inpari Sidenuk variety can increase the highest grain yield.plot⁻¹ and yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively and was significantly

different from other varieties. While the other yield components were not significantly different between the varieties tested. This is caused the highest leaf area found in the Inpari Sidenuk variety of 26.27 cm^2 compared to the others (Table 1). The extent of the leaves will affect the amount of chlorophyll in forming photosynthates and increased lowland rice grain yield. According to ²⁵stated that the plants will adaption to the stress of low light intensity by increasing the efficiency of light capture through increasing the amount of chlorophyll per unit leaf area. The increasing rate of photosynthesis the higher carbohydrates are formed. The carbohydrates that are available in large quantities will increase chlorophyll synthesis will result that chlorophyll rate is higher in shaded leaves.

The results were indicated that the highest percentage of empty grain was found in the plant spacing of 25 cm x 20 cm amounted to 29.61%. The plant spacing of 25 cm x 25 cm (J_2) can significantly increase the panicle length, number of grains.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. This causes the plant spacing of 25 cm x 25 cm (J_2) contributing to the highest increase in the physiological character (fresh weight stover.clump⁻¹) of lowland rice plants compared to other plant spacing (Table 2). The effect of plant spacing on the physiological response will have an impact on the yield component of lowland rice yield in integrated with mature-4 of smallholder oil palm. Rice plants are shaded stress or low light intensity will experience changes in morphological, anatomical, physiological, and biochemical characters that will have an impact on crop production. According to ²⁶the light intensity will affect the shape and anatomy of leaves including epidermal and mesophyll cell types. ²⁷stated that the shaded leaves of plants will be thinner and wider compared to leaves of plants in normal light intensity, which is caused by the reduction in the palisade layer and mesophyll cells. ^{28,29}statedthat the physiological response of plants to shaded-stress, namely increasing the number of chloroplasts per leaf area and increasing the amount of chlorophyll in chloroplasts. ³⁰stated

that the low light intensity will affect chloroplasts in plants, namely an increase in the number of chloroplasts per cell, the volume of chloroplasts and thylakoid membranes, and stack granum as in *Gusmania monostachia*. ³¹stated that the shade was caused by the low activity of Rubisco whereas functions to bind CO₂ and Ribulose biphosphate (RuBP) in the Calvin cycle which produces 3-PGA. ³²stated that the low light intensity during flowering in rice caused a decrease in carbohydrate, protein, auxin, proline, and cytokinin content, however, it increased the gibberellins and dissolved N content in panicles. ³³stated that the reduction of photosynthate at low light intensity can be related to the high resistance of stomata and mesophyll cells to CO₂ exchange. In low light conditions were decreased the carboxylase and RuBP activity.

CONCLUSION

Inpari Sidenuk variety can increase grain yield.plot⁻¹ and yield.ha⁻¹ the highest of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can increase the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm (J₂) can increase the panicle length, number of grain.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The interaction of lowland rice varieties with plant spacing was not significantly the vegetative, physiological, and yield components in integrated with mature-4 of smallholder oil palm. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm can be used in integrated with mature-4 of smallholder oil palm in support of increased yield.ha⁻¹ and food self-sufficiency.

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SIGNIFICANCE STATEMENT

The research discovered the integration of lowland rice varieties with oil palm which can be beneficial for smallholder and plantations of oil palm for helping the government in order to support the food self-sufficiency.

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Revisi 2

Evaluation Report

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17.	Significance Statement	• Overall OK	The significance statement was changed.
18.	References	• Author didn't incorporate the following changes • Provide DOI or URL of all listed references. DOI is mandatory, without DOI your article will not be able for further processing. If you can't find DOI or URL then replace your references with suitable and active references	The references was changed according to Asian Journal of Plant Science format.

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Effect of Varieties with Plant Spacing in Integration Smallholder Oil

Palm on Growth, Physiological, and Yield of Lowland Rice

Vegetative, Physiological, and Yield Components observation of Rice Varieties with Specific Plant Spacing In Integrated w Mature-4 by Smallholder of Oil Palm

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Hamidah Hanum Email: -	Improve of the Introduction and Results

Running title: Integrated of Lowland Rice in Oil Palm

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ABSTRACT

Background and Objective: The effort of lowland rice need to be supported by the program integration of lowland rice with oil palm plants to food self-sufficiency. The research was aimed to obtain the vegetative, physiological, and yield components of several varieties of lowland rice with specific plant spacing in integrated mature-4 by smallholder of oil palm.

Material and Methods: The research used the split-plot design with the main-plot is the plant spacing ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plots is the rice varieties ($V_1 = \text{Inpara 2}$; $V_2 = \text{Inpari 4}$; $V_3 = \text{Inpari 10}$; and $V_4 = \text{Inpari Sidenuk}$). Parameters were analyzed by ANOVA and the means effect was followed by DMRT at level of 5%.

Results: The Inpari Sidenuk variety significantly increased the grain yield.plot⁻¹ and the highest yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of 25 cm x 25 cm (J_2), 25 cm x 30 cm (J_3), and 25 cm x 35 cm (J_4) can significantly increase the fresh weight stover.clump⁻¹ of 13.53 g; 13.29 g; and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm can increase the panicle length, number of grain.panicle⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing.

Conclusion: The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm has the potential to be recommended in integrated with mature-4 of smallholder oil palm to increasing yield and food self-sufficiency.

Keywords: Growth, integration, physiological, plant spacing, lowland rice varieties, smallholder oil palm, yield

INTRODUCTION

The lowland rice yield in Indonesia over the past 5 years (2014-2018) has fluctuated¹. One of the provinces in Indonesia as a contributor to rice yield is North Sumatra Province, however, the lowland yield is classified as fluctuated from 2006 until 2018. The lowland rice yield fluctuated can be caused by the rice area also has fluctuations². The decrease in the area of lowland rice harvesting can be caused by the conversion of lowland rice to oil palm plantations. The conversion of lowland rice to plantation plants such as oil palm and rubber. Anggari *et al.*³ stated that the cause of the public executes the conversion of lowland rice into oil palm plantations such as the risk in lowland rice farming is higher, and economic factors are more profitable in Trumon sub-District, South Aceh District). Fauzi⁴ stated that the lowland rice conversion is the lack of certainty in the price of lowland rice so that the income from rice is lower compared to oil palm and rubber plantation.

The decrease in the lowland rice land will have an impact on the deficit of rice stocks in Indonesia. Rice demand in 2025 is expected to increase by 60%. In supply to food demand then the government through the ministry of agriculture has been focusing on seven major commodities in the program to achieve self-sufficiency and increased yield at the 2017 year through the program “UPSUS PAJALE” and plans to form 1 million hectares of lowland rice land until 2019 year⁵.

The effort to form 1 million hectares of lowland rice need to be supported by the use mature of oil palm plantations through the program integration of lowland rice with oil palm plants. The application of lowland rice as intercropping among oil palm has been reviewed by previous researchers without harming the plantations. Bratkovich *et al.*⁶ stated that the oil palm can survive in flooded up to 3 months. Colmer and Voesenek⁷, Dewi⁸ reported that the oil palm is classified as very tolerant of flooded. Aminudin *et al.*⁹ stated that the oil palm can survive in inundation conditions up to 50 days. The results showed that oil palm in flooded

conditions is very beneficial for the growth and development of lowland rice with ± 3 months to harvest.

Therefore the existence of previous research, it is expected that lowland rice plants will also be able to grow and produce until harvesting even though several shaded by oil palm canopy. However, lowland rice in the conditions of shaded will experience disruption of physiological and biochemical processes. Chozin *et al.*¹⁰ stated that one of the inhibitors to the growth and production of upland rice in intercropping is the occurrence of light deficits reaching the rice canopy. Low light intensity results in disruption of the rate of photosynthesis and carbohydrate synthesis and results in a decrease in the rate of growth and yield of plants.

Therefore several alternatives are needed to increase the yield of lowland rice with the integration of oil palms including the use of shade-tolerant varieties and plant spacing. It is very difficult to find publications and references of research results with the planting system of lowland rice in the oil palm plants. According to Murty and Sahu¹¹, Cabuslay *et al.*¹², Lubis *et al.*¹³ stated that the planting upland rice in the immature of oil palm area as land use can reduce yield by up to 70 until 90% in shade conditions > 50% compared to normal light. Warjido *et al.*¹⁴ stated that the plant spacing is important in optimizing the use of sunlight for photosynthesis, with the result that plants will have balanced growing space. Magfiroh *et al.*¹⁵ stated that the plant spacing of 25 cm x 25 cm can significantly increase panicle length and the number of grain.panicle⁻¹ of lowland rice of 3.60% and 8.71%, respectively compared to plant spacing of 20 cm x 20 cm.

. This research was aimed to obtain high-yielding lowland rice varieties at plant spacing with integrated mature-4 of smallholder oil palm.

MATERIAL AND METHODS

Land Management

The research integration of lowland rice and mature-4 of oil palm oil with the number population of 72 trees or 0.50 ha which is located at Titi Payung Street, Hamparan Perak sub-District, Deli Serdang District, North Sumatra Province, Indonesia in April until August 2017. This research was conducted with the processing of the land using the hand tractor. The soil was cultivated three folds as deep as 20 cm, using the rotary plow.

Plot Size and Research Design

The plot was made with a size of 10 m x 20 m. This research used the split plot design with the main-plot is the plant spacing of 4 levels ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plot is lowland rice varieties consisting of 4 varieties, namely ($V_1 = \text{Inpara 2}$; ($V_2 = \text{Inpari 4}$; ($V_3 = \text{Inpari 10}$; and ($V_4 = \text{Inpari Sidenuk}$). The treatment of this research was used the three replications.

Seeding and Planting Process

Seed rice was soaked in water for 24 hours and then drained for 12 hours. The seeds that have germinated are then sown in the nursery and after 2 weeks were moved to the plot. After the seedlings are 3 weeks and planting was conducted in the plot following the treatment in manually, each hole only one plant. The number of plants in the sub-plot was 24 plants with five plant samples.

Plant Management

The transfer of seedlings, water has flowed into the plot with the height of 5 cm until the plant is 45 days old. The insertion was performed during 2 weeks after planting (WAP) or before the basic fertilization. Weeding was conducted in the initial period until 21 and 42 WAP used the manually when weeds have 3 to 4 leaves, then flooded for 1 day. Fertilization was conducted with N 90 kg.ha⁻¹, TSP 50 kg.ha⁻¹, and KCl 50 kg.ha⁻¹. The phosphorus and

potassium fertilizer are given before transplanting seedlings, while N fertilizer is given 3 folds such as a week after transplanting, 40 days after transplanting and 65 to 70 days old. Pest and disease control is only conducted when the symptoms of an attack have reached the economic threshold using insecticides, and fungicides that are adjusted to pests/diseases.

Harvesting

Two weeks before harvesting the lowland rice water is drained so that the rice grains mature quickly. Harvesting was conducted manually using the sickle at the mature plant physiology marked visually in lowland rice, such as rice grains were yellowed ranged from 90 until 95% or grain moisture content ranged from 22 until 27%.

Parameters and Analysis

Data Vegetative

Components

The parameters of the vegetative components such as plant height (cm), number of tillers, and leaf area (cm²). Plant height and number of tillers were measured at 4 and 6 WAP. Leaf area was measured at harvest by taking a flag leaf from each sample and calculated by the formula $p \times l \times 0.75$.

Physiological Components

The parameters of the physiological component such as leaf chlorophyll content (chlorophyll a, b, and total), fresh weight stover.clump⁻¹ (g), and dry weight stover.clump⁻¹ (g). The chlorophyll a, b, and total were measured using the UV-Vis spectrophotometer¹⁶. The extraction of chlorophyll was conducted with acetone 80%, the leaves are weighed 0.1 g, then crushed in the mortal, inserted 10 ml acetone, filtered with Whatman filter paper. The filtrate was measured for absorbance at 645 nm and 663 nm. The calculation of chlorophyll a, b and total were used the formula:

$$\text{Chlorophyll a} = (12.7 \times A_{663} - 2.69 \times A_{645}) \times 10^{-1} \quad (1)$$

$$\text{Chlorophyll b} = (22.9 \times A_{645} - 4.68 \times A_{663}) \times 10^{-1} \quad (2)$$

$$\text{Chlorophyll total} = (8.02 \times A_{663} + 20.2 \times A_{645}) \times 10^{-1} \quad (3)$$

Fresh weight stover.clump⁻¹ was cut from the base of the stem at the end of the research, be weighed, then put into a brown envelope and dried in the sun for 3 days and oven at 60°C for 72 hours to obtain the dry weight stover.clump⁻¹ after which it was weighed using analytical scales.

Yield Component

The parameters of the yield component such as the number of productive tillers, panicle length (cm), number of grain.panicle⁻¹, filled grain (%), empty grain (%), 1000 grains weight (g), grain yield.plot⁻¹ (kg), and yield.ha⁻¹ (tons). The number of productive tillers was measured when the plants were flowered, by counting the tillers produce panicles. Panicle length was measured when the plant has been harvested by measuring the panicle formed.clump⁻¹ from the base to the end of the panicle. The number of grains.panicle⁻¹ was calculated by dividing the total number of grains in the sample with the total number of panicles. The percentage of filled grains was calculated by dividing the number of filled grains from all panicles of the sample with the total number of grains. The percentage of empty grains was calculated by dividing the number of empty grains from all panicles of the sample with the total number of grains. The 1000 grains weight was measured by drying up to moisture content of 14% and take by 1000 rice grains randomly then weighed. The grain yield.plot⁻¹ was calculated by weighing the filled grain in each plot and weighed using analytical scales. The yield.ha⁻¹ was calculated by converting the average grain yield.plot⁻¹ using the formula:

$$\text{Yield/ha}^{-1} = \frac{\text{Average Yield.Plot}^{-1}}{\text{Plot Area}} \times \text{Area of 1 ha} \quad (4)$$

Parameters were analyzed with analysis of variance (ANOVA) and the significant effect was followed by Duncan's Multiple Range Test (DMRT) at the level of 5%.

RESULTS AND DISCUSSION

Growth Components

The results of the ANOVA showed that the varieties, plant spacing and their interaction not significantly influence the increase in plant height, number of tillers and leaf area of lowland rice in integrated with mature-4 of smallholder oil palm (Table 1).

Table 1. Growth components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Treatment	Plant Height (cm)		Number of Tillers		Leaf Area (cm ²)
	4 WAP	6 WAP	4 WAP	6 WAP	
Varieties (V)					
V ₁ = Inpara 2	61.08 ns	83.37 ns	6.28 ns	10.00 ns	24.40 ns
V ₂ = Inpari 4	66.73 ns	84.31 ns	7.15 ns	12.23 ns	22.90 ns
V ₃ = Inpari 10	68.53 ns	85.55 ns	6.85 ns	12.00 ns	25.41 ns
V ₄ = Inpari Sidenuk	70.85 ns	90.36 ns	6.81 ns	11.60 ns	26.27 ns
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	66.28 ns	84.38 ns	6.41 ns	11.05 ns	23.04 ns
J ₂ = (25 cm × 25 cm)	67.12 ns	86.64 ns	6.68 ns	11.06 ns	36.04 ns
J ₃ = (25 cm × 30 cm)	64.91 ns	85.30 ns	7.18 ns	11.64 ns	20.09 ns
J ₄ = (25 cm × 35 cm)	68.90 ns	87.26 ns	6.83 ns	12.08 ns	19.81 ns

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test. Weeks after planting (WAP). ns = not significant.

The results showed that the plant height of lowland rice varieties was integrated with mature-4 of smallholder oil palm highest were found in the Inpari Sidenuk variety (V₄) of 70.85 cm and 90.36 cm, respectively at 4 and 6 WAP. The plant spacing of 25 cm x 35 cm (J₄) is the spacing that the highest of plant height amounted to 68.90 cm and 87.26 cm, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in Inpari 4 variety (V₂) of 7.15 tillers and 12.23 tillers, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 30 cm (J₃) of 7.18 tillers at 4 WAP, and found in 25 cm × 35 cm (J₄) of 12.08 tillers at 6 WAP. The leaf area of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the Inpari Sidenuk variety (V₄) of 26.27 cm², and plant spacing of 25 cm x 25 cm (J₂) amounted to 38.97 cm².

Rice variety of Inpari Sidenuk (V₄) and plant spacing of 25 cm x 25 cm (J₂) in integration with mature-4 of smallholder oil palm can adapt to the low light intensity, this is evidenced by the highest leaf area compared to the others treatment. According to Levitt¹⁷ stated that the plant adaptation to shade can be conducted through avoidance that is associated with response to changes in the anatomy and morphology of leaves for photosynthesis efficient. The efficiency of increasing light capture can be conducted by increasing the area of light capture, by increasing the leaf area. Yeo¹⁸, Santoso *et al.*¹⁹, Sopandie *et al.*²⁰ stated that the low light in upland rice cause disturbed metabolic processes which have implications for decreasing the rate of photosynthesis and carbohydrate synthesis.

Physiological Components

The results of the ANOVA showed that the plant spacing significantly increased the fresh weight stover.clump⁻¹, however not significantly increased the chlorophyll a, b, total, and dry weight stover.clump⁻¹ of lowland rice. Varieties and their interactions not significant effect in increasing the physiological component of lowland rice in integrated with mature-4 of smallholder oil palm (Table 2).

Table 2. Physiological component of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Perlakuan	Chlorophyll (mg.cm ²)			Fresh weight stover.clump ⁻¹ (g)	Dry weight stover.clump ⁻¹ (g)
	a	b	Total		
Varieties (V)					
V ₁ = Inpara 2	3.25 ns	4.52 ns	7.77 ns	12.70 ns	3.30 ns
V ₂ = Inpari 4	3.57 ns	4.54 ns	8.11 ns	12.44 ns	3.45 ns
V ₃ = Inpari 10	3.53 ns	4.17 ns	7.70 ns	12.18 ns	3.95 ns
V ₄ = Inpari Sidenuk	3.48 ns	4.16 ns	7.64 ns	13.51 ns	3.55 ns
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	3.32 ns	4.00 ns	7.32 ns	10.80 b	3.08 ns
J ₂ = (25 cm × 25 cm)	3.35 ns	4.37 ns	7.72 ns	13.53 a	3.78 ns
J ₃ = (25 cm × 30 cm)	3.57 ns	4.44 ns	8.00 ns	13.29 a	3.73 ns
J ₄ = (25 cm × 35 cm)	3.59 ns	4.59 ns	8.18 ns	13.22 a	3.66 ns

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test. ns = not significant.

The results showed that the Inpari 4 variety had higher levels of chlorophyll a, b, and total of 3.57 mg.cm², 4.54 mg.cm², and 8.11 mg.cm², respectively compared to other varieties. The chlorophyll a, b, and total of lowland rice varieties were integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 35 cm(J₄) of 3.59 mg.cm², 4.59 mg.cm², and 8.18 mg.cm², respectively compared to other plant spacing. Lowland rice varieties are very tolerant of shading were showed that the change in morphological character (leaf area) as lower compared to sensitive varieties. The effect of plant spacing of 25 cm × 35 cm (J₄) has an impact on the amount of light that can be absorbed by lowland rice because the spacing between plants is relatively wider compared to others plant spacing. Chozin *et al.*¹⁰, Sopandie²¹ stated that the character of rice was decreased in low light conditions both sensitive and tolerant varieties, however, the tolerant varieties, the decrease is relatively lower. Asmamaw²² stated that the plant spacing of 30 cm x 20 cm on rice variety Nerica-4 has higher chlorophyll content of 1.35-fold compared to the plant spacing of 20 cm x 10 cm at 107 days after treatment.

The results showed that the fresh weight stover.clump⁻¹ of lowland rice varieties the highest in integrated with mature-4 of smallholder oil palm was found in the Inpari Sidenuk (V₄) variety and was not significantly different of the other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can significantly increased the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. The plant spacing of J₂-J₄ is the plant spacing were wider compared to J₁. The extent of plant spacing used will have an impact on the ability of rice plants to absorb light, nutrients, and water. According to Barri²³ the plant spacing system affects the light, wind, and nutrients obtained by plants which in turn gives a different effect on plant growth and yield parameters. Pedersen and Lauer²⁴ stated that the soybean yield was increased by 4% with increasing row spacing from 19 cm to 76 cm in the first year.

The results showed that the dry weight stover.clump⁻¹ of lowland rice varieties in integrated with mature-4 of smallholder oil palm the highest was found in the Inpari 10 variety (V₃) of 3.95 g and was not significant compared to other varieties. The plant spacing of 25 cm x 25 cm (J₂) gives effect the dry weight stover.clump⁻¹ the highest of 3.78 g and was not significant compared to other plant spacing.

Yield Components

The lowland rice varieties in integrated with mature-4 of smallholder oil palm can significantly increase grain yield.plot⁻¹ and yield.ha⁻¹. Plant spacing can significantly increase the lowland rice yield components except for the number of productive tillers, while their interaction had not significantly affect on yield components (Table 3).

Table 3. Yield components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Parameters	Treatment			
	V ₁	V ₂	V ₃	V ₄
	Inpara 2	Inpari 4	Inpari 10	Inpari Sidenuk
Number of productive tillers	8.00 ns	7.24 ns	8.41 ns	10.05 ns
Panicle length (cm)	21.98 ns	22.34 ns	22.83 ns	22.46 ns
number of grain.panicle ⁻¹	118.70 ns	122.05 ns	134.38 ns	140.27 ns
Filled grain (%)	72.52 ns	77.81 ns	87.39 ns	87.25 ns
Empty grain (%)	32.05 ns	27.97 ns	9.76 ns	8.08 ns
1000 grains weight (g)	20.66 ns	22.20 ns	24.04 ns	24.89 ns
Grain yield.plot ⁻¹ (kg)	0.11 d	0.10 c	0.38 b	0.42 a
Yield.ha ⁻¹ (ton)	0.85 c	0.83 c	3.02 b	3.36 a
	J ₁	J ₂	J ₃	J ₄
	(25 × 20 cm)	(25 × 25 cm)	(25 × 30 cm)	(25 × 35 cm)
Number of productive tillers	6.80 ns	10.28 ns	9.00 ns	7.61 ns
Panicle length (cm)	19.88 d	24.68 a	23.09 b	21.97 c
number of grain.panicle ⁻¹	108.35 d	145.00 a	137.40 b	124.65 c
Filled grain (%)	72.09 d	89.76 a	85.05 b	78.07 c
Empty grain (%)	29.62 a	17.56 b	16.04 c	14.64 d
1000 grains weight (g)	19.77 c	25.31 a	23.54 b	23.18 b
Grain yield.plot ⁻¹ (kg)	0.22 d	0.31a	0.25 b	0.23 c
Yield.ha ⁻¹ (ton)	1.76 d	2.50 a	2.00 b	1.81 c

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test. ns = not significant.

The results were indicated that the Inpari Sidenuk variety can increase the highest grain yield.plot⁻¹ and yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively and was significantly

different from other varieties. While the other yield components were not significantly different between the varieties tested. This is caused the highest leaf area found in the Inpari Sidenuk variety of 26.27 cm² compared to the others (Table 1). The extent of the leaves will affect the amount of chlorophyll in forming photosynthates and increased lowland rice grain yield. According to Johnston and Onwueme²⁵ stated that the plants will adaption to the stress of low light intensity by increasing the efficiency of light capture through increasing the amount of chlorophyll per unit leaf area. The increasing rate of photosynthesis the higher carbohydrates are formed. The carbohydrates that are available in large quantities will increase chlorophyll synthesis will result that chlorophyll rate is higher in shaded leaves.

The results were indicated that the highest percentage of empty grain was found in the plant spacing of 25 cm x 20 cm amounted to 29.61%. The plant spacing of 25 cm x 25 cm (J₂) can significantly increased the panicle length, number of grains.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. This causes the plant spacing of 25 cm x 25 cm (J₂) contributing to the highest increase in the physiological character (fresh weight stover.clump⁻¹) of lowland rice plants compared to other plant spacing (Table 2). The effect of plant spacing on the physiological response will have an impact on the yield component of lowland rice yield in integrated with mature-4 of smallholder oil palm. Rice plants are shaded stress or low light intensity will experience changes in morphological, anatomical, physiological, and biochemical characters that will have an impact on crop production. According to Vogelmann and Martin²⁶ the light intensity will affect the shape and anatomy of leaves including epidermal and mesophyll cell types. Taiz and Zeiger²⁷ stated that the shaded leaves of plants will be thinner and wider compared to leaves of plants in normal light intensity, which is caused by the reduction in the palisade layer and mesophyll cells. Hale and Orchutt²⁸, Okada *et al.*²⁹ stated that the physiological response of plants to shaded-stress, namely increasing the number of chloroplasts per leaf area

and increasing the amount of chlorophyll in chloroplasts. Maxwell *et al.*³⁰ stated that the low light intensity will affect chloroplasts in plants, such as an increase in the number of chloroplasts per cell, the volume of chloroplasts and thylakoid membranes, and stack granum as in *Gusmania monostachia*. Brüggemann and Dauborn³¹ stated that the shade was caused by the low activity of Rubisco whereas functions to bind CO₂ and Ribulose biphosphate (RuBP) in the Calvin cycle which produces 3-PGA. Sopandie *et al.*³² stated that the low light intensity during flowering in rice caused a decrease in carbohydrate, protein, auxin, proline, and cytokinin content, however, it was increased the gibberellins and dissolved N content in panicles. Thorne and Koller³³ stated that the reduction of photosynthate at low light intensity can be related to the high resistance of stomata and mesophyll cells to CO₂ exchange. In low light conditions were decreased the carboxylase and RuBP activity.

CONCLUSION

Inpari Sidenuk variety can increase grain yield.plot⁻¹ and yield.ha⁻¹ the highest of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can increase the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm (J₂) can increase the panicle length, number of grain.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The interaction of lowland rice varieties with plant spacing was not significantly the vegetative, physiological, and yield components in integrated with mature-4 of smallholder oil palm. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm can be used in integrated with mature-4 of smallholder oil palm in support of increased yield.ha⁻¹ and food self-sufficiency.

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SIGNIFICANCE STATEMENT

The research discovered the integration of lowland rice varieties with oil palm which can be beneficial for smallholder and plantations of oil palm for helping the government in order to support the food self-sufficiency.

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Revisi 3

Evaluation Report

Final Decision: Reconsider for Evaluation after Modifications and Clarifications

Article No.:103764-AJPS-ANSI Article Type:

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7.	Abstract	• Overall OK	Thank you
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10.	Materials and Methods	Provide citation with reference of the formula used in Materials and Method section.	Thank you
11.	Results	Overall OK	Thank you
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14.	Discussion	Overall OK	Thank you
15.	Conclusion	Overall OK	Thank you
16.	Acknowledgement	Overall OK	-
17.	Significance Statement	Overall OK	The significance statement was changed.
18.	References	- Do not add conference proceedings as a reference. Replace the proceedings with original full length article reference. - DOI is missing. Author should provide DOI or URL of reference number 28.	The references was re-changed according to Asian Journal of Plant Science format.

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Incorporate all the recommended modifications

Vegetative, Physiological, and Yield Components observation of Rice Varieties with Specific Plant Spacing In Integrated Mature-4 by Smallholder of Oil Palm

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Running title: Integrated of Lowland Rice in Oil Palm

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Abstract

Background and Objective: The effort of lowland rice need to be supported by the program integration of lowland rice with oil palm plants to food self-sufficiency. The research was aimed to obtain the vegetative, physiological, and yield components of several varieties of lowland rice with specific plant spacing in integrated mature-4 by smallholder of oil palm.

Material and Methods: The research used the split-plot design with the main-plot is the plant spacing ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plots is the rice varieties ($V_1 = \text{Inpara 2}$; $V_2 = \text{Inpari 4}$; $V_3 = \text{Inpari 10}$; and $V_4 = \text{Inpari Sidenuk}$). Parameters were analyzed by ANOVA and the means effect was followed by DMRT at level of 5%. **Results:** The Inpari Sidenuk variety significantly increased the grain yield.plot⁻¹ and the highest yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of 25 cm x 25 cm (J_2), 25 cm x 30 cm (J_3), and 25 cm x 35 cm (J_4) can significantly increase the fresh weight stover.clump⁻¹ of 13.53 g; 13.29 g; and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm can increase the panicle length, number of grain.panicle⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. **Conclusion:** The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm has the potential to be recommended in integrated with mature-4 of smallholder oil palm to increasing yield and food self-sufficiency.

Keywords: Growth, integration, physiological, plant spacing, lowland rice varieties, smallholder oil palm, yield

INTRODUCTION

The lowland rice yield in Indonesia over the past 5 years (2014-2018) has fluctuated¹. One of the provinces in Indonesia as a contributor to rice yield is North Sumatra Province, however, the lowland yield is classified as fluctuated from 2006 until 2018. The lowland rice yield fluctuated can be caused by the rice area also has fluctuations². The decrease in the area of lowland rice harvesting can be caused by the conversion of lowland rice to oil palm plantations. The conversion of lowland rice to plantation plants such as oil palm and rubber. Anggari *et al.*³ stated that the cause of the public executes the conversion of lowland rice into oil palm plantations such as the risk in lowland rice farming is higher, and economic factors are more profitable in Trumon sub-District, South Aceh District). Fauzi⁴ stated that the lowland rice conversion is the lack of certainty in the price of lowland rice so that the income from rice is lower compared to oil palm and rubber plantation.

The decrease in the lowland rice land will have an impact on the deficit of rice stocks in Indonesia. Rice demand in 2025 is expected to increase by 60%. In supply to food demand then the government through the ministry of agriculture has been focusing on seven major commodities in the program to achieve self-sufficiency and increased yield at the 2017 year through the program “UPSUS PAJALE” and plans to form 1 million hectares of lowland rice land until 2019 year⁵.

The effort to form 1 million hectares of lowland rice need to be supported by the use mature of oil palm plantations through the program integration of lowland rice with oil palm plants. The application of lowland rice as intercropping among oil palm has been reviewed by previous researchers without harming the plantations. Bratkovich *et al.*⁶ stated that the oil palm can survive in flooded up to 3 months. Colmer and Voesenek⁷, Dewi⁸ reported that the oil palm is classified as very tolerant of flooded. Aminudin *et al.*⁹ stated that the oil palm can survive in inundation conditions up to 50 days. The results showed that oil palm in flooded

conditions is very beneficial for the growth and development of lowland rice with ± 3 months to harvest.

Therefore the existence of previous research, it is expected that lowland rice plants will also be able to grow and produce until harvesting even though several shaded by oil palm canopy. However, lowland rice in the conditions of shaded will experience disruption of physiological and biochemical processes. Chozin *et al.*¹⁰ stated that one of the inhibitors to the growth and production of upland rice in intercropping is the occurrence of light deficits reaching the rice canopy. Low light intensity results in disruption of the rate of photosynthesis and carbohydrate synthesis and results in a decrease in the rate of growth and yield of plants.

Therefore several alternatives are needed to increase the yield of lowland rice with the integration of oil palms including the use of shade-tolerant varieties and plant spacing. It is very difficult to find publications and references of research results with the planting system of lowland rice in the oil palm plants. According to Murty and Sahu¹¹, Cabuslay *et al.*¹², Lubis *et al.*¹³ stated that the planting upland rice in the immature of oil palm area as land use can reduce yield by up to 70 until 90% in shade conditions > 50% compared to normal light. Warjido *et al.*¹⁴ stated that the plant spacing is important in optimizing the use of sunlight for photosynthesis, with the result that plants will have balanced growing space. Magfiroh *et al.*¹⁵ stated that the plant spacing of 25 cm x 25 cm can significantly increase panicle length and the number of grain.panicle⁻¹ of lowland rice of 3.60% and 8.71%, respectively compared to plant spacing of 20 cm x 20 cm.

. This research was aimed to obtain high-yielding lowland rice varieties at plant spacing with integrated mature-4 of smallholder oil palm.

MATERIALS AND METHODS

Land management: The research integration of lowland rice and mature-4 of oil palm oil with the number population of 72 trees or 0.50 ha which is located at Titi Payung Street, Hamparan Perak sub-District, Deli Serdang District, North Sumatra Province, Indonesia in April until August 2017. This research was conducted with the processing of the land using the hand tractor. The soil was cultivated three folds as deep as 20 cm, using the rotary plow.

Plot size and research design: The plot was made with a size of 10 m x 20 m. This research used the split plot design with the main-plot is the plant spacing of 4 levels ($J_1 = 25 \text{ cm} \times 20 \text{ cm}$; $J_2 = 25 \text{ cm} \times 25 \text{ cm}$; $J_3 = 25 \text{ cm} \times 30 \text{ cm}$; and $J_4 = 25 \text{ cm} \times 35 \text{ cm}$) and sub-plot is lowland rice varieties consisting of 4 varieties, namely ($V_1 = \text{Inpara 2}$; ($V_2 = \text{Inpari 4}$; ($V_3 = \text{Inpari 10}$; and ($V_4 = \text{Inpari Sidenuk}$). The treatment of this research was used the three replications.

Seeding and planting process: Seed rice was soaked in water for 24 hours and then drained for 12 hours. The seeds that have germinated are then sown in the nursery and after 2 weeks were moved to the plot. After the seedlings are 3 weeks and planting was conducted in the plot following the treatment in manually, each hole only one plant. The number of plants in the sub-plot was 24 plants with five plant samples.

Plant management: The transfer of seedlings, water has flowed into the plot with the height of 5 cm until the plant is 45 days old. The insertion was performed during 2 weeks after planting (WAP) or before the basic fertilization. Weeding was conducted in the initial period until 21 and 42 WAP used the manually when weeds have 3 to 4 leaves, then flooded for 1 day. Fertilization was conducted with N 90 kg.ha⁻¹, TSP 50 kg.ha⁻¹, and KCl 50 kg.ha⁻¹. The phosphorus and potassium fertilizer are given before transplanting seedlings, while N fertilizer is given 3 folds such as a week after transplanting, 40 days after transplanting and 65 to 70 days old. Pest and disease control is only conducted when the symptoms of an attack have reached the economic threshold using insecticides, and fungicides that are adjusted to pests/diseases.

Harvesting: Two weeks before harvesting the lowland rice water is drained so that the rice grains mature quickly. Harvesting was conducted manually using the sickle at the mature plant physiology marked visually in lowland rice, such as rice grains were yellowed ranged from 90 until 95% or grain moisture content ranged from 22 until 27%.

Parameters and analysis data

Vegetative components: The parameters of the vegetative components such as plant height (cm), number of tillers, and leaf area (cm²). Plant height and number of tillers were measured at 4 and 6 WAP. Leaf area was measured at harvest by taking a flag leaf from each sample and calculated by the formula $p \times l \times 0.75$.

Physiological components: The parameters of the physiological component such as leaf chlorophyll content (chlorophyll a, b, and total), fresh weight stover.clump⁻¹ (g), and dry weight stover.clump⁻¹ (g). The chlorophyll a, b, and total were measured using the UV-Vis spectrophotometer¹⁶. The extraction of chlorophyll was conducted with acetone 80%, the leaves are weighed 0.1 g, then crushed in the mortal, inserted 10 ml acetone, filtered with Whatman filter paper. The filtrate was measured for absorbance at 645 nm and 663 nm. The calculation of chlorophyll a, b and total were used the formula:

$$\text{Chlorophyll a} = (12.7 \times A_{663} - 2.69 \times A_{645}) \times 10^{-1} \quad (1)$$

$$\text{Chlorophyll b} = (22.9 \times A_{645} - 4.68 \times A_{663}) \times 10^{-1} \quad (2)$$

$$\text{Chlorophyll total} = (8.02 \times A_{663} + 20.2 \times A_{645}) \times 10^{-1} \quad (3)$$

Fresh weight stover.clump⁻¹ was cut from the base of the stem at the end of the research, be weighed, then put into a brown envelope and dried in the sun for 3 days and oven at 60°C for 72 hours to obtain the dry weight stover.clump⁻¹ after which it was weighed using analytical scales.

Yield component: The parameters of the yield component such as the number of productive tillers, panicle length (cm), number of grain.panicle⁻¹, filled grain (%), empty grain (%), 1000 grains weight (g), grain yield.plot⁻¹ (kg), and yield.ha⁻¹ (tons). The number of productive tillers was measured when the plants were flowered, by counting the tillers produce panicles. Panicle length was measured when the plant has been harvested by measuring the panicle formed.clump⁻¹ from the base to the end of the panicle. The number of grains.panicle⁻¹ was calculated by dividing the total number of grains in the sample with the total number of panicles. The percentage of filled grains was calculated by dividing the number of filled grains from all panicles of the sample with the total number of grains. The percentage of empty grains was calculated by dividing the number of empty grains from all panicles of the sample with the total number of grains. The 1000 grains weight was measured by drying up to moisture content of 14% and take by 1000 rice grains randomly then weighed. The grain yield.plot⁻¹ was calculated by weighing the filled grain in each plot and weighed using analytical scales. The yield.ha⁻¹ was calculated by converting the average grain yield.plot⁻¹ using the formula:

$$\text{Yield/ha}^{-1} = \frac{\text{Average Yield.Plot}^{-1}}{\text{Plot Area}} \times \text{Area of 1 ha} \quad (4)$$

Parameters were analyzed with analysis of variance (ANOVA) and the significant effect was followed by Duncan's Multiple Range Test (DMRT) at the level of 5%.

RESULTS AND DISCUSSION

Growth components: The results of the ANOVA showed that the varieties, plant spacing and their interaction not significantly influence the increase in plant height, number of tillers and leaf area of lowland rice in integrated with mature-4 of smallholder oil palm (Table 1).

Table 1. Growth components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Treatment	Plant Height (cm)		Number of Tillers		Leaf Area (cm ²)
	4 WAP	6 WAP	4 WAP	6 WAP	
Varieties (V)					
V ₁ = Inpara 2	61.08 ns	83.37 ns	6.28 ns	10.00 ns	24.40 ns
V ₂ = Inpari 4	66.73 ns	84.31 ns	7.15 ns	12.23 ns	22.90 ns
V ₃ = Inpari 10	68.53 ns	85.55 ns	6.85 ns	12.00 ns	25.41 ns
V ₄ = Inpari Sidenuk	70.85 ns	90.36 ns	6.81 ns	11.60 ns	26.27 ns
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	66.28 ns	84.38 ns	6.41 ns	11.05 ns	23.04 ns
J ₂ = (25 cm × 25 cm)	67.12 ns	86.64 ns	6.68 ns	11.06 ns	36.04 ns
J ₃ = (25 cm × 30 cm)	64.91 ns	85.30 ns	7.18 ns	11.64 ns	20.09 ns
J ₄ = (25 cm × 35 cm)	68.90 ns	87.26 ns	6.83 ns	12.08 ns	19.81 ns

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test. Weeks after planting (WAP). ns = not significant.

The results showed that the plant height of lowland rice varieties was integrated with mature-4 of smallholder oil palm highest were found in the Inpari Sidenuk variety (V₄) of 70.85 cm and 90.36 cm, respectively at 4 and 6 WAP. The plant spacing of 25 cm x 35 cm (J₄) is the spacing that the highest of plant height amounted to 68.90 cm and 87.26 cm, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in Inpari 4 variety (V₂) of 7.15 tillers and 12.23 tillers, respectively at 4 and 6 WAP. The number of tillers of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 30 cm (J₃) of 7.18 tillers at 4 WAP, and found in 25 cm × 35 cm (J₄) of 12.08 tillers at 6 WAP. The leaf area of lowland rice varieties was integrated with mature-4 of smallholder oil palm the highest was found in the Inpari Sidenuk variety (V₄) of 26.27 cm², and plant spacing of 25 cm x 25 cm (J₂) amounted to 38.97 cm².

Rice variety of Inpari Sidenuk (V₄) and plant spacing of 25 cm x 25 cm (J₂) in integration with mature-4 of smallholder oil palm can adapt to the low light intensity, this is evidenced by the highest leaf area compared to the others treatment. According to Levitt¹⁷ stated that the plant adaptation to shade can be conducted through avoidance that is associated with response to changes in the anatomy and morphology of leaves for photosynthesis efficient. The efficiency of increasing light capture can be conducted by increasing the area of light capture, by increasing the leaf area. Yeo¹⁸, Santoso *et al.*¹⁹, Sopandie *et al.*²⁰ stated that the low light in upland rice cause disturbed metabolic processes which have implications for decreasing the rate of photosynthesis and carbohydrate synthesis.

Physiological Components: The results of the ANOVA showed that the plant spacing significantly increased the fresh weight stover.clump⁻¹, however not significantly increased the chlorophyll a, b, total, and dry weight stover.clump⁻¹ of lowland rice. Varieties and their interactions not significant effect in increasing the physiological component of lowland rice in integrated with mature-4 of smallholder oil palm (Table 2).

Table 2. Physiological component of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Perlakuan	Chlorophyll (mg.cm ²)			Fresh weight stover.clump ⁻¹ (g)	Dry weight stover.clump ⁻¹ (g)
	a	b	Total		
Varieties (V)					
V ₁ = Inpara 2	3.25 ns	4.52 ns	7.77 ns	12.70 ns	3.30 ns
V ₂ = Inpari 4	3.57 ns	4.54 ns	8.11 ns	12.44 ns	3.45 ns
V ₃ = Inpari 10	3.53 ns	4.17 ns	7.70 ns	12.18 ns	3.95 ns
V ₄ = Inpari Sidenuk	3.48 ns	4.16 ns	7.64 ns	13.51 ns	3.55 ns
Plant Spacing (J)					
J ₁ = (25 cm × 20 cm)	3.32 ns	4.00 ns	7.32 ns	10.80 b	3.08 ns
J ₂ = (25 cm × 25 cm)	3.35 ns	4.37 ns	7.72 ns	13.53 a	3.78 ns
J ₃ = (25 cm × 30 cm)	3.57 ns	4.44 ns	8.00 ns	13.29 a	3.73 ns
J ₄ = (25 cm × 35 cm)	3.59 ns	4.59 ns	8.18 ns	13.22 a	3.66 ns

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test. ns = not significant.

The results showed that the Inpari 4 variety had higher levels of chlorophyll a, b, and total of 3.57 mg.cm², 4.54 mg.cm², and 8.11 mg.cm², respectively compared to other

varieties. The chlorophyll a, b, and total of lowland rice varieties were integrated with mature-4 of smallholder oil palm the highest was found in the plant spacing of 25 cm × 35 cm(J₄) of 3.59 mg.cm², 4.59 mg.cm², and 8.18 mg.cm², respectively compared to other plant spacing. Lowland rice varieties are very tolerant of shading were showed that the change in morphological character (leaf area) as lower compared to sensitive varieties. The effect of plant spacing of 25 cm × 35 cm (J₄) has an impact on the amount of light that can be absorbed by lowland rice because the spacing between plants is relatively wider compared to others plant spacing. Chozin *et al.*¹⁰, Sopandie²¹ stated that the character of rice was decreased in low light conditions both sensitive and tolerant varieties, however, the tolerant varieties, the decrease is relatively lower. Asmamaw²² stated that the plant spacing of 30 cm x 20 cm on rice variety Nerica-4 has higher chlorophyll content of 1.35-fold compared to the plant spacing of 20 cm x 10 cm at 107 days after treatment.

The results showed that the fresh weight stover.clump⁻¹ of lowland rice varieties the highest in integrated with mature-4 of smallholder oil palm was found in the Inpari Sidenuk (V₄) variety and was not significantly different of the other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can significantly increased the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. The plant spacing of J₂-J₄ is the plant spacing were wider compared to J₁. The extent of plant spacing used will have an impact on the ability of rice plants to absorb light, nutrients, and water. According to Barri²³ the plant spacing system affects the light, wind, and nutrients obtained by plants which in turn gives a different effect on plant growth and yield parameters. Pedersen and Lauer²⁴ stated that the soybean yield was increased by 4% with increasing row spacing from 19 cm to 76 cm in the first year.

The results showed that the dry weight stover.clump⁻¹ of lowland rice varieties in integrated with mature-4 of smallholder oil palm the highest was found in the Inpari 10

variety (V₃) of 3.95 g and was not significant compared to other varieties. The plant spacing of 25 cm x 25 cm (J₂) gives effect the dry weight stover.clump⁻¹ the highest of 3.78 g and was not significant compared to other plant spacing.

Yield components: The lowland rice varieties in integrated with mature-4 of smallholder oil palm can significantly increase grain yield.plot⁻¹ and yield.ha⁻¹. Plant spacing can significantly increase the lowland rice yield components except for the number of productive tillers, while their interaction had not significantly affect on yield components (Table 3).

Table 3. Yield components of lowland rice varieties in integrated with mature-4 of smallholder oil palm.

Parameters	Treatment			
	V ₁	V ₂	V ₃	V ₄
	Inpara 2	Inpari 4	Inpari 10	Inpari Sidenuk
Number of productive tillers	8.00 ns	7.24 ns	8.41 ns	10.05 ns
Panicle length (cm)	21.98 ns	22.34 ns	22.83 ns	22.46 ns
number of grain.panicle ⁻¹	118.70 ns	122.05 ns	134.38 ns	140.27 ns
Filled grain (%)	72.52 ns	77.81 ns	87.39 ns	87.25 ns
Empty grain (%)	32.05 ns	27.97 ns	9.76 ns	8.08 ns
1000 grains weight (g)	20.66 ns	22.20 ns	24.04 ns	24.89 ns
Grain yield.plot ⁻¹ (kg)	0.11 d	0.10 c	0.38 b	0.42 a
Yield.ha ⁻¹ (ton)	0.85 c	0.83 c	3.02 b	3.36 a
	J ₁	J ₂	J ₃	J ₄
	(25 × 20 cm)	(25 × 25 cm)	(25 × 30 cm)	(25 × 35 cm)
Number of productive tillers	6.80 ns	10.28 ns	9.00 ns	7.61 ns
Panicle length (cm)	19.88 d	24.68 a	23.09 b	21.97 c
number of grain.panicle ⁻¹	108.35 d	145.00 a	137.40 b	124.65 c
Filled grain (%)	72.09 d	89.76 a	85.05 b	78.07 c
Empty grain (%)	29.62 a	17.56 b	16.04 c	14.64 d
1000 grains weight (g)	19.77 c	25.31 a	23.54 b	23.18 b
Grain yield.plot ⁻¹ (kg)	0.22 d	0.31a	0.25 b	0.23 c
Yield.ha ⁻¹ (ton)	1.76 d	2.50 a	2.00 b	1.81 c

Note: The means followed by the same letter are not significantly different at the 5% level by Duncan Multiple Range Test. ns = not significant.

The results were indicated that the Inpari Sidenuk variety can increase the highest grain yield.plot⁻¹ and yield.ha⁻¹ of 0.42 kg and 3.36 tons, respectively and was significantly different from other varieties. While the other yield components were not significantly different between the varieties tested. This is caused the highest leaf area found in the Inpari Sidenuk variety of 26.27 cm² compared to the others (Table 1). The extent of the leaves will

affect the amount of chlorophyll in forming photosynthates and increased lowland rice grain yield. According to Johnston and Onwueme²⁵ stated that the plants will adapt to the stress of low light intensity by increasing the efficiency of light capture through increasing the amount of chlorophyll per unit leaf area. The increasing rate of photosynthesis the higher carbohydrates are formed. The carbohydrates that are available in large quantities will increase chlorophyll synthesis will result that chlorophyll rate is higher in shaded leaves.

The results were indicated that the highest percentage of empty grain was found in the plant spacing of 25 cm x 20 cm amounted to 29.61%. The plant spacing of 25 cm x 25 cm (J₂) can significantly increase the panicle length, number of grains.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. This causes the plant spacing of 25 cm x 25 cm (J₂) contributing to the highest increase in the physiological character (fresh weight stover.clump⁻¹) of lowland rice plants compared to other plant spacing (Table 2). The effect of plant spacing on the physiological response will have an impact on the yield component of lowland rice yield in integrated with mature-4 of smallholder oil palm. Rice plants are shaded stress or low light intensity will experience changes in morphological, anatomical, physiological, and biochemical characters that will have an impact on crop production. According to Vogelmann and Martin²⁶ the light intensity will affect the shape and anatomy of leaves including epidermal and mesophyll cell types. Taiz and Zeiger²⁷ stated that the shaded leaves of plants will be thinner and wider compared to leaves of plants in normal light intensity, which is caused by the reduction in the palisade layer and mesophyll cells. Hale and Orchutt²⁸, Okada *et al.*²⁹ stated that the physiological response of plants to shaded-stress, namely increasing the number of chloroplasts per leaf area and increasing the amount of chlorophyll in chloroplasts. Maxwell *et al.*³⁰ stated that the low light intensity will affect chloroplasts in plants, such as an increase in the number of chloroplasts per cell, the volume of chloroplasts and thylakoid membranes, and stack granum

as in *Gusmania monostachia*. Brüggemann and Dauborn³¹ stated that the shade was caused by the low activity of Rubisco whereas functions to bind CO₂ and Ribulose biphosphate (RuBP) in the Calvin cycle which produces 3-PGA. Sopandie *et al.*³² stated that the low light intensity during flowering in rice caused a decrease in carbohydrate, protein, auxin, proline, and cytokinin content, however, it was increased the gibberellins and dissolved N content in panicles. Thorne and Koller³³ stated that the reduction of photosynthate at low light intensity can be related to the high resistance of stomata and mesophyll cells to CO₂ exchange. In low light conditions were decreased the carboxylase and RuBP activity.

CONCLUSION

Inpari Sidenuk variety can increase grain yield.plot⁻¹ and yield.ha⁻¹ the highest of 0.42 kg and 3.36 tons, respectively compared to other varieties. The plant spacing of J₂-J₄ (25 cm x 25 cm; 25 cm x 30 cm; 25 cm x 35 cm) can increase the fresh weight stover.clump⁻¹ of 13.53 g, 13.29 g, and 13.22 g, respectively. In overall, plant spacing of 25 cm x 25 cm (J₂) can increase the panicle length, number of grain.panicles⁻¹, percentage of filled grain, 1000 grains weight, grain yield.plot⁻¹, and yield.ha⁻¹ compared to other plant spacing. The interaction of lowland rice varieties with plant spacing was not significantly the vegetative, physiological, and yield components in integrated with mature-4 of smallholder oil palm. The use of Inpari Sidenuk variety with the plant spacing of 25 cm x 25 cm can be used in integrated with mature-4 of smallholder oil palm in support of increased yield.ha⁻¹ and food self-sufficiency.

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SIGNIFICANCE STATEMENT

The research discovered the integration of lowland rice varieties with oil palm which can be beneficial for smallholder and plantations of oil palm for helping the government in order to support the food self-sufficiency.

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Research Article

Vegetative, Physiological and Yield Components Observation of Rice Varieties with Specific Plant Spacing in Integrated Mature-4 by Smallholder of Oil Palm

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