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Integrated cropping system of rice with oil palm: local and new varieties

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Abstract

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This study aims to determine the effectiveness of several cropping systems on the growth and production of high yielding local and high yielding new varieties rice among oil palm plants. This research was conducted in rainfed lowland area that has been planted with oil palm age 4 years in Tiga-Tiga Sub-village, Sungai Sentang Village, Kualuh Hilir District, Labuhanbatu Utara Regency. The research was conducted on October 2015 to March 2016. The study uses Split-Split Plots Design (SSPD) with the main plots of oil palm are 143 plants/ha (P_1), 107 plants/ha (P_2), 72 plants/ha (P_3) populations. Sub-plots are Legowo 2:1 (J_1), Legowo 4:1 (J_2), Tegel 20x20 cm (J_3), Tegel 25x25 cm (J_4) cropping systems and sub-subplots are Kuku Balam (V_1), Ramos (V_2), Inpari 10 (V_3) and Inpari Sidenuk (V_4) varieties rice. The results that the sum of oil palm populations, cropping system, and interaction cannot increase yield production/ha. The varieties factor can increase the yield production/ha. The character of Kuku Balam and Ramos varieties rice (local) have an effect on increasing plant height, leaf area, panicle length and the sum of grain/panicle. The character of Inpari Sidenuk varieties rice (new) have an effect on the sum of productive tillers (7.20), grain weight of 1000 seeds (34.44 g) and harvest index value (0.55). The heritability value of rice character is high (52.28 to 99.57%). Kuku Balam varieties have yield production amount 4.47 tons/ha and more adaptive in conditions among oil palm plants.

Keywords: cropping system; oil palm; rice varieties

Introduction

Indonesia, which has a population of 237 million people and 95% of population's main food is cooked rice. Consumption of rice around 137 kg/capita/year, then predicted the need for rice in 2020 for the people of Indonesia reached 35.97 million tons/year (Barus, 2013). Therefore a step to yield increase of rice per hectare or a year is needed. It is estimated that demand for rice in 2025 will increase 60% compared to present in order to meet these food needs. One of the causes of decreasing rice production is the conversion of land into oil palm plants. The decrease of rice production in Labuhanbatu Utara, Sumatera Utara Province amounted to 11,016 tons of dry unhulled rice or around 5 728 t from 2010-2011 (Alridiwirsah, 2013). The decrease of rice-field area in Sumatera Utara in the decade (2003 and 2013) effect conversion to oil palm reached 52,243 ha (BPS-Statistics of Sumatera Utara Province, 2014). The decrease in rice production will affect the population imbalance in food needs.

Based on the data from Directorate General of Estate Crops shows that the area of oil palm plantations in Indonesia in 2017 amounted to 12 307 677 ha and especially Sumatera Utara Province of 1 474 897 ha. The area of oil palm plantation (immature) in 2017 in Sumatera Utara was of 180 513 ha (12.24%). Based on the data, the product of agricultural systems produced only CPO and derivatives, meaning that are monoculture. The monoculture farming system may be at risk of loss. This happens because the selling price of agricultural products in general is very fluctuating at any time. Therefore, it is necessary to diversification in reducing the risk of dependence on monoculture agricultural business activities. One of them is through the integration strategy of oil palm plantation with rice at age < 4 years (immature-1). The integration strategy of oil palm plantation with rice is one of the promising business diversification alternatives in increasing local and regional food production as well as supporting government programs in food self-sufficiency.

Increased productivity of plants can be done among others by using seeds of high yielding varieties. Thus, efforts made to optimize food production (rice) with collaboration on oil palm plants at age < 4 years through high yielding varieties. The purpose of this study was to determine the effectiveness of several cropping systems on the growth and production of high yielding local and high yielding new varieties of rice among oil palm plants.

Materials and Methods

Materials

The research was conducted in rainfed lowland area that has been planted with oil palm aged 4 years (immature-1) in Tiga-Tiga Sub-village, Sungai Sentang Village, Kualuh Hilir District, Labuhanbatu Utara Regency. The research was conducted in the period October 2015 –March 2016. Materials of this research are rice of high yielding local varieties/HYLV (Kuku Balam, Ramos) and high yielding new varieties/HYNV (Inpari 10, Inpari Sidenuk), oil palm plant (immature) with sum of population/ha (143, 107 and 72 plants/ha).

Experimental Design

Study was prepared based on the Split-Split Plots Design (SSPD) where the main plot is the oil palm population with 3 levels (P_1: sum of 100% oil palm population = 143 plants/ha, P_2: sum of 75% oil palm population = 107 plants/ha, P_3: sum of 50% oil palm population = 72 plants/ha); sub-plots is a cropping system with 4 levels (J_1: Legowo 2: 1 system, J_2: Legowo 4: 1 system, J_3: Tegel 20 x 20 cm system, and J_4: Tegel 25 x 25 cm system) and sub-sub-plots are 4 varieties (V_1: Kuku Balam, V_2: Ramos, V_3: Inpari 10, and V_4: Inpari Sidenuk).

Statistic

Data used in this study were plant height 4, 6 and 8 Weeks After Planted (WAP), leaf area, the sum of productive tillers, panicle length, the sum of grain/panicle, grain weight of 1000 seeds, harvest index value, genetic diversity and yield production/ha. Data were analysed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at the level 5% with IBM SPSS Statistics 20 software. The genetic diversity by calculating the variance phenotype (σ^2p), variance genotype (σ^2g) from ANOVA (Hallauer & Miranda, 1988). Calculate the phenotypic variance (σ^2p) and genotypic variance (σ^2g) are presented in Table 1.

Table 1. Model analysis of variance and mean square value

Source	df	Sum of Squares (SS)	Mean Square (MS)	Estimates (Mean Square)
Block (B)	(b-1)	SS of B	MS of B	$\sigma^2e + g\,\sigma^2r$
Genotype (G)	(g-1)	SS of G	MS of G	$\sigma^2e + r\,\sigma^2g$
Error (E)	(b-1) (g-1)	SS of E	MS of E	σ^2e
Total (T)	gb-1	SS of T		

The Coefficient of Genotype Variance (CGV) and Coefficient of Phenotype Variance (CPV) using the formula:

$$CGV = \frac{\sqrt{\sigma^2 g}}{X} \times 100\%$$

$$CGV = \frac{\sqrt{\sigma^2 p}}{X} \times 100\%$$

$$\sigma^2p = \sigma^2g + \sigma^2e$$

$$\sigma^2g = \frac{\text{MS of G} - \text{MS of E}}{\text{replicate}}$$

$$\sigma^2e = \text{MS of E}$$

Heritability value is calculated using the following formula:

$$h^2 = \frac{\sigma^2 g}{\sigma^2 p} \quad \text{(Allard, 1960)}$$

According Stansfield (1983), heritability category: High, if the H value > 50%

Medium, if the H value is between 20%-50%, and Low, if the H value < 20%

Results and Discussion

The plant height of several varieties rice between oil palm plants is at 4, 6, and 8 WAP (Fig. 1). Based on observations in the field was found that Ramos varieties were significantly different from 4 to 8 WAP compared to other varieties. The high-

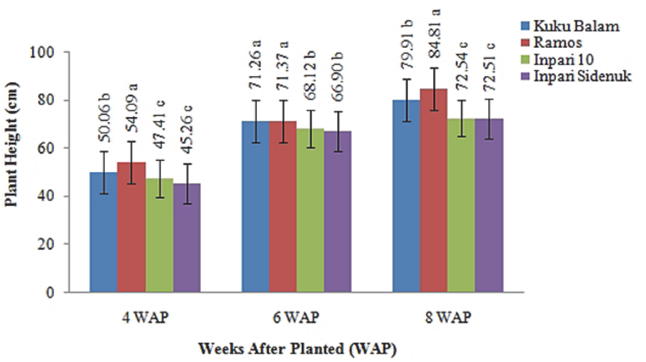

Fig. 1. The plant height of rice varieties from high yielding local and high yielding new varieties among oil palm plants. Vertical bars indicate ±SE. Means significantly different according to DMRT at level 5%

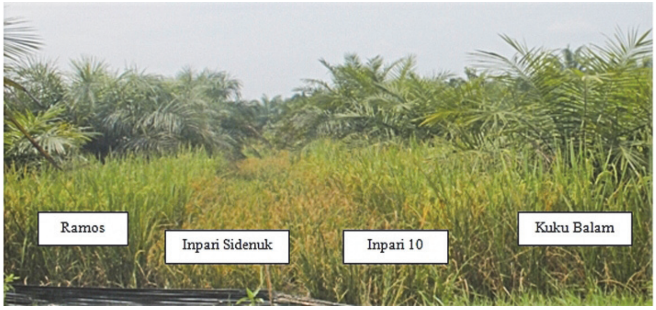

Fig. 2. The high yielding local varieties (Kuku Balam and Ramos) and high yielding new varieties (Inpari 10 and Inpari Sidenuk) among oil palm plants during the generative phase

est plants of 4 to 8 WAP are found in the Ramos varieties. The high growth of rice plants variation from each variety caused by genetic factors, so the growth of the field also gives a different appearance, especially in terms of plant height growth. Differences in the period of generative growth of high yielding local and high yielding new varieties of rice are shown in Fig. 2. This is in accordance with the literature (Sujitno et al., 2011) which states plant height is influenced by genetic properties and environmental conditions of plant growth.

Leaf area, the sum of productive tillers, panicle length, the sum of grain/panicle, grain weight of 1000 seeds, and harvest index value of several high yielding local, as well as high yielding new varieties, rice among oil palm plants (Table 2). It was found that the high yielding local varieties rice (Kuku Balam and Ramos) has leaf area, panicle length and the sum of grains/panicles that are significantly different from the high yielding new varieties. Kuku Balam varieties have the highest leaf area characteristic (32.26 cm^2) compared to other varieties. The extent of leaf area Kuku Balam varieties linear with the sum of grain/panicle (178.38) and the yield production/ha is 4.47 tons/ha. This increase in leaf area is one of the adaptations of rice among oil palm plants in capturing the sunlight used for photosynthesis produce. This is consistent with literature (Hale & Orcutt,1987) which states that crop adaptation to shade can be achieved through two ways of increasing the leaf area as an effort to reduce metabolite use and reduce the amount of light transmitted and reflected.

The highest panicle length is the Ramos high yielding local varieties (27.39 cm) and different from the high yielding new varieties. This shows that the yield production of rice depends very much on the panicle length that grows on the productive tillers; it is because the panicle is where the grains are attached. In general the longer the panicle of rice will be more grains of rice-produced. This is due to external and internal factors affecting the qualitative and quantitative characteristics of plants. This is consistent with literature (Gardner et al., 1991) which states that internal factors are factors influenced by genetic traits or derivative properties such as plant age, plant morphology, yield power, the storage capacity of food reserves, resistance to disease and others. External factors are environmental factors, such as climate, soil and biotic factors.

The highest sum of grain/panicle is the Kuku Balam high yielding local varieties (178.38) and different from high yielding new varieties. The difference in the sum of grains/panicle is thought to be caused by the genetic influence of each different cultivar. But apart from genetic influences, environmental factors also affect the sum of grains/panicle

Table 2. The leaf area, sum of produktive tillers, panicle length, sum of grain/panicle, grain weight of 1000 seeds, and harvest index value from high yielding local and high yielding new varieties rice among oil palm plants.

Rice Varieties	Leaf area (cm^2)	Sum of produktive tillers	Panicle length (cm)	Sum of grain/ panicle	Grain weight of 1000 seeds (g)	Harvest index value
Kuku Balam	32.90 a	5.87 b	27.28 a	178.38 a	27.29 c	0.43 ab
Ramos	32.26 a	5.27 b	27.39 a	178.15 a	26.99 c	0.35 b
Inpari 10	23.69 b	5.91 b	23.29 b	125.26 b	32.31 b	0.48 ab
Inpari Sidenuk	22.78 b	7.20 a	22.55 b	124.53 b	34.44 a	0.55 a

Note: The numbers that are not followed by the same letter in a same column or row, means significantly different according to DMRT at 5% level of each variety in the formation of flowers on each panicle. This is consistent with literature (Darti, 1992) which states that nature of each genetic and environment from which the variety grows, will affect the density of each panicle, the sum of grains/panicle will also affect the amount of grain formed.

The Inpari Sidenuk high yielding new varieties have the sum of productive tillers (7.20), grain weight of 1000 seeds (34.44 g) and harvest index value (0.55) highest compared to other rice varieties. This is caused when the vegetative phase of the tillers grows rapidly until the puppy reaches the maximum and part of the tillers form panicles. This is consistent with literature (Setyono, 1997) which states that productive tillers are saplings of rice that develops further from the tillers of rice which will then form panicles.

The Inpari Sidenuk high yielding new varieties have the highest grain weight of 1000 seeds (34.44 g) compared to other rice varieties. The weight difference grain weight of 1000 seeds produced is related to the ability of each variety to absorb the available nutrients, especially the phosphorus (P) nutrients. This suggests that the genetic and environmental roles may affect the production of rice among oil palm plants. This is consistent with literature (Warisno, 1998) which states that the different P absorption will cause the photosynthate produced by different rice so that the photosynthetic yields that are translocated for the filling needs of seed are different. Seed will be formed perfectly if there is enough carbohydrate accumulation; P nutrients required 75% of the rice during its generative period. In addition, Kamal (2001) also stated that the difference in total results is due to differences in the genetic composition of each rice cultivar, so the response to the environment is also different.

The harvest index value of Inpari Sidenuk varieties was significantly different from other varieties (0.55). Results of harvest index of all varieties are in the range of 0.35 to 0.55. This harvest index value is strongly influenced by the grain weight with total biomass obtained by each variety. This is consistent with literature (Zapata, 1983) which states that the harvest index value is the ratio of grain weight with total biomass. The yield production can be increased by increasing the yield index or increasing the total dry weight production.

The genotype and phenotype variability, genotype and phenotype variance coefficients, and heritability of high yielding local and high yielding new varieties rice among oil palm plants are shown in Table 3. It is found that 7 characters observed have high heritability value. The predictive heritability value of a character needs to be known in order to determine which genotype or environmental factors play a role in the character's appearance. The leaf area character amount is 94.89%, influenced by genetic factor and 5.11% by the environmental factor. The sum of productive tillers character amount 89.55% influenced by genetic factor and 10.45% by the environmental factor. The panicle length character amount is 98.63%, influenced by genetic factors and 1.37% by the environmental factors. The sum of grain/panicle character amount 99.57% influenced by genetic factor and 0.43% by the environmental factor. The grain weight of 1000 seeds character amount 88.98% influenced by genetic factors and 11.02% by the environmental factors. The grain production/plot character amount is 52.28%, influenced by genetic factor and 47.72% by the environmental factor. The harvest index value character amount is 77.42%, influenced by genetic factor and 22.58% by the environmental factor. From 7 characters observed, the dominant character (h^2> 80%) was influenced by genetic factors such as leaf area, the sum of productive tillers, panicle length, the sum of grains/panicle, and grain weight/panicle. While the dominant character influenced by environment factor is the grain production/plot and harvest index value.

The yield production/ha of high yielding local and high yielding new varieties of rice among oil palm plants are shown of Fig. 3. It is found that the yield production/ha of

Table 3. Genotypic (σ^2g) and phenotypic (σ^2p) variance, coefficient of genotypic variance (CGV), coefficient of phenotypic variance (CPV) and heritability on all observed traits of high yielding local and high yielding new varieties rice among oil palm plants

Quantitative traits	Genotypic variance (σ^2g)	Phenotypic variance (σ^2p)	CGV (%)	CPV (%)	Broad sense heritability/h^2 (%)
Leaf area (cm^2)	345.07	363.67	66.56	68.33	94.89 H
Sum of produktive tillers	7.66	8.55	45.67	48.26	89.55 H
Panicle length (cm)	78.74	79.83	35.31	35.55	98.63 H
Sum of grain/panicle	11378.01	11427.08	70.37	70.52	99.57 H
Grain weight of 1000 seeds (g)	158.12	177.70	41.56	44.05	88.98 H
Yield production/plot	0.62	1.20	34.22	47.33	52.28 H
Harvest index value	0.07	0.09	59.63	67.77	77.42 H

Note: H (High), M (Medium), L (Low)

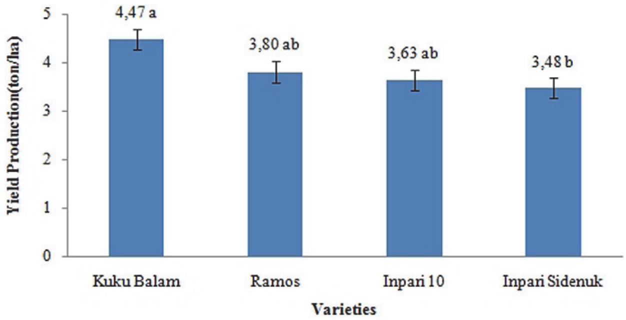

Fig. 3. The yield production/ha from high yielding local and high yielding new varieties among oil palm plants

Kuku Balam high yielding local varieties is significantly different than other varieties. The yield production/ha of rice in all varieties among oil palm plants decreased by 4.89% (Kuku Balam), 20.83% (Ramos), 57.29% (Inpari 10) and 61.76% (Inpari Sidenuk) compared to conditions with 100% light intensity at the release of varieties. This indicates that Kuku Balam high yielding local varieties have the potential to be cultivated under conditions among oil palm plants. The Kuku Balam genetic varieties are more adaptive to low light in producing photosynthesis.

Conclusion

The sum of oil palm population, cropping system, and interaction cannot increase yield production/ha. The varieties factor can affect the observed variables. The character of Kuku Balam and Ramos varieties rice (local) have been the effect of increasing plant height, leaf area, panicle length and the sum of grain/panicle. The Inpari Sidenuk varieties rice (new) have been the effect on the sum of productive tillers (7.20), grain weight of 1000 seeds (34.44 g) and harvest index value (0.55). The heritability value of rice is high (52.28 to 99.57%). The Kuku Balam varieties rice have yield production/ha amount 4.47 tons/ha and more adaptive in conditions among oil palm plants.

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