Alley cropping in immature oil palm

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Abstract. Limitation of planting area can be managed by optimizing the immature with alley cropping. The purpose of this research is to analyze the increase in crop productivity with a variety of fertilizer doses and analyze dosage used on intercrops. The experiment was conducted at KUD Tunas Muda, Siak Regency, Riau, November 2018 until March 2019. This experiment used a nested randomized complete block design (RCBD) the treatment consisted of two treatment factors, fertilization treatment as the main factor and crop treatment as a sub-plot. Fertilization treatment consisted of three levels, P1 (fertilizer recommendation), P2 (manure 5 tons ha⁻¹ + 1/2 fertilizer recommendation) and P3 (manure 2.5 tons ha⁻¹ + 1/2 fertilizer recommendation). The treatment of plants consisted of four levels, T1 (without the crop), T2 (soybean monoculture), T3 (intercropping corn + soybean (1:2)), T4 (monoculture corn). The intercropping pattern in oil palm plantations can increase land productivity. The soybean intercropping patterns affect yield components. The P3 treatment (2.5 tons ha⁻¹ manure + 1/2 recommended fertilizer) is the optimum fertilizer dosage for corn and soybean cultivation in the oil palm area (TBM-1) by intercropping based on the results of the land equality ratio of 1.76.

Keywords: corn, intercropping soybean, oil palm,

1. Introduction

Land area and palm oil production increase every year. The area of oil palm plantations in 2014-2017 was 10.75 million ha and 12.30 million ha while palm oil production was 29.28 million tons and 35.36 million tons [8]. The area of oil palm in 2012 to 2016 reached 10.13 million ha and 11.91 million ha [5]. The increase in the area of oil palm causes the limited area for planting other commodities, one of them is food crops. The limited area of planting can be controlled by optimizing the land of oil palm immature plantations (TBM). According to [15] oil palm plants have not produced a year old age (TBM-1) there is an open space of around 60-75% and in TBM-2 there are around 45-50%.

Land optimization can be done in the open space contained in the TBM oil palm area. Optimization of oil palm plantations can be done using intercropping cultivation techniques by utilizing the distance between oil palm plants and planting annual crops. According to [13] soybean plants can be intercropped in the alley between oil palm plants. This planting system, in addition to increasing land productivity, also provides financial benefits for planters. According to [18] intercropping planting with two or more suitable plant species is able to utilize planting space and time efficiently and can reduce the occurrence of nutrient competition.

Planting corn among coconut plants can increase farmers’ income [2]. Planting soybean intercropping in the area of oil palm does not have a negative impact on the vegetative growth of oil palm (TBM). The
water and nutrient uptake competition between soybean and oil palm is still limited because the roots of soybean plants are still beyond the reach of the roots of oil palm plants. According to amelioration and fertilization are important components in improving soil conditions in acid sulphate land, especially in newly opened locations. Amelioration material can be in the form of lime or dolomite or organic matter, ash husk and sawdust.

Giving ameliorant manure, petroganik and dolomite in dry land can increase soybean yields compared without ameliorant. Ameliorant material for chicken manure gives the highest soybean yield of 2.4 ton/ha compared to petroganic ameliorant, dolomite and farmer patterns (without ameliorant) [14] Giving CaCO3 lime is the best material to overcome the acidity of Ultisol soil. The provision of chicken manure is better than the administration of CaCO3 lime and green manure on the parameters of increasing growth and production of corn [3]. This study aims to (1) analyze the increase in crop productivity with a variety of fertilizer doses, (2) analyze dosage used on intercrops.

2. Materials and Methods

2.1. Experiment procedure

The study was conducted in the people's oil palm plantation, KUD Tunas Muda, Teluk Merbau Village, Dayun District, Siak Regency, Riau. When the research starts in November 2018 - March 2019. This experiment used a nested randomized complete block design (RCBD) the treatment consisted of two treatment factors, fertilization treatment as the main factor and crop treatment as a plot child. Fertilization treatment consisted of three levels, P1 (fertilizer recommendation), P2 (manure 5 tons/ha + 1/2 fertilizer recommendation) and P3 (manure 2.5 tons/ha + 1/2 fertilizer recommendation). The treatment of plants consisted of four levels, T1 (without the crop), T2 (soybean monoculture), T3 (intercropping corn + soyben (1:2)), T4 (monoculture corn). The repeated treatment combination consisted of three replications so that there were 36 experimental units.

The linear additive model of the design to be used is as follows:

\[ Y(ij)k = \mu + \alpha_i + \gamma i/k + \beta_j + (\alpha \beta)ij + \varepsilon(ij)k \]

The fertilizing treatment used during the experiment is as follows:

a. Soybean Plant [19]

- P1 = 50 kg urea ha\(^{-1}\) + 100 kg sp-36 ha\(^{-1}\) + 100 kg kcl ha\(^{-1}\)
- P2 = 5 ton ha\(^{-1}\) manure + 25 kg urea ha\(^{-1}\) + 50 kg sp-36 ha\(^{-1}\) + 50 kg kcl ha\(^{-1}\)
- P3 = 2.5 ton ha\(^{-1}\) manure + 25 kg urea ha\(^{-1}\) + 50 kg sp-36 ha\(^{-1}\) + 50 kcl ha\(^{-1}\)

b. Corn plant [4]

- P1 = 350 kg urea ha\(^{-1}\) + 100 kg sp-36 ha\(^{-1}\) + 150 kg kcl ha\(^{-1}\)
- P2 = 5 ton ha\(^{-1}\) manure + 175 kg urea ha\(^{-1}\) + 50 kg sp-36 ha\(^{-1}\) + 75 kg kcl ha\(^{-1}\)
- P3 = 2.5 ton ha\(^{-1}\) manure + 175 kg urea ha\(^{-1}\) + 50 kg sp-36 ha\(^{-1}\) + 75 kg kcl ha\(^{-1}\)

Intercropping of corn and soybeans in a ratio of 1: 2, 1 row of corn and 2 rows of soybeans using a spacing of 70 cm x 30 cm refers to the research of [1]. Soybean harvesting can be done when the plant dries completely, the stem starts to harden, the pods turn hard and turn brown in color according to the study of [12]. Planting corn by making seed planting holes in accordance with the spacing. The recommended spacing is 70 cm x 20 cm with one seed per hole. Harvesting of maize can be done when the plant reaches 100 days after planting (HST), referring to the [4]. Harvesting of corn can be done when the corn is ripe which is marked by the leaves and stems of the plant begin to dry and brown. The characteristics of mature cob are leaves that have started to turn yellow, yellowish brown hair and brown hair. In addition, the presence of a black layer at the base of the corn seeds (black layer) refers to the research of [23].
2.2. Observation
Observation was carried out for ± 4 months. Observations were made on the sample plants in the experimental unit. Observations were made based on morphological, production, physiology and land use efficiency variables. The morphological responses observed in corn and soybean plants consisted of vegetative components which included: plant growing power. Components of maize production include: weight of cob without weight (g), weight of 100 dry seeds per plot (g) and production (tons / ha). The components of soybean production include: weight of 100 seeds per plot (g) and production (tons / ha). Physiological analysis including stomata density and chlorophyll a, chlorophyll b and total chlorophyll content observed in corn and soybean plants. Land use efficiency The method of calculating land use efficiency refers to research [17] Land use efficiency is determined using the NKL (Land Equality Ratio). NKL values can indicate the productivity of monocultures and intercropping planted land. If NKL is obtained greater 1 (> 1), shows that intercropping patterns are more efficient than monocultures in land use.

3. Result and discussion

3.1. Alley cropping growth
The growth of intercropping by applying monoculture and intercropping cultivation patterns in the TBM-1 oil palm land showed 82.92% monoculture soybean growing power, 71.1% monoculture corn, 82.73% intercropping soybeans and 55.73% intercropping corn. The percentage of soybean growing power in monoculture and intercropping patterns is high compared to corn. The growth potential of maize cultivation in monoculture and intercropping patterns there is a very significant difference, the percentage of maize maize intercropping ability is low compared to monoculture corn. This is likely due to the low viability of the excess used. The condition of the percentage of growth of plants is low so that the replanting is done until the population is full with the difference in the age of the first plant with plants produced by embroidery different from 1 week after planting (MST). According to [22] seeds are categorized as high levels of viability if the germination is > 85% and low <75%. According to [11] the level of seed vigor is influenced by the shelf life where when the seeds are stored things that can occur vigor are more rapidly decreasing than the growing power or vice versa the power of seed growth is still high while the vigor is decreasing.

3.2. Alley cropping production
Intercropped plants affect weights without corn husk but not affect for weights of 100 seeds and productivity. The highest average weight without corn husk was 238.00 g (monoculture) and the lowest was 226.11 g (intercropping). The highest average weight of 100 seeds was 31.18 g (monoculture) and the lowest was 6.44 g (intercropping). The highest average corn productivity was 6.72 tonsha-1 (monoculture) and the lowest was 10.20 tonsha-1 (intercropping) (Table 1). This is likely due to nutrient competition that occurs in intercropping treatment so that the resulting productivity is low when compared to monoculture treatments. This is in line with the study of [2] the treatment of corn as an intercrop between coconut plants showed low dry yield. According to [6] the obstacle faced in the application of intercropping is that the yields obtained are lower compared to monoculture. This is caused by poor shade, physical condition and soil fertility. According to [20] the average weight of 100 seeds of corn plants with monoculture treatments had higher yields compared to intercropping treatments.
Table 1. Component of corn crop production

| Treatment      | Weight without corn husk (g) | Weight of 100 seeds (g) | Productivity ton ha⁻¹ |
|----------------|------------------------------|-------------------------|------------------------|
| **Corn**       |                              |                         |                        |
| Monoculture    |                              |                         |                        |
| P1             | 232.00b                      | 31.49                   | 6.72                   |
| P2             | 214.00b                      | 31.07                   | 6.98                   |
| P3             | 268.00a                      | 30.97                   | 6.45                   |
| **Mean**       | **238.00**                   | **31.18**               | **6.72**               |
| Intercropping  |                              |                         |                        |
| P1             | 275.33a                      | 30.43                   | 6.27                   |
| P2             | 218.33b                      | 30.81                   | 6.51                   |
| P3             | 184.67c                      | 30.54                   | 6.53                   |
| **Mean**       | **226.11**                   | **30.59**               | **6.44**               |

Notes: Numbers followed by different letters in the same column indicate different significantly based on the Duncan Multiple Range Test (DMRT) α = 5%

The intercrops affect the weight of 100 seeds and productivity. The highest average weight of 100 seeds was 14.79 g (monoculture) and the lowest was 12.43 g (intercropping). The highest average soybean production was 2.15 ton ha⁻¹ (monoculture) and the lowest was 1.03 ton ha⁻¹ (intercropping) (Table 2). According to [16] the higher the shade level, the resulting yield component will decrease, the decrease is influenced by the amount of interest generated. The less the number of flowers formed, the smaller number of pods produced. This will affect the weight of 100 seeds.

Table 2. Components of soybean production

| Treatment      | Weight of 100 seeds (g) | Productivity ton ha⁻¹ |
|----------------|-------------------------|------------------------|
| **Soybean**    |                         |                        |
| Monoculture    |                         |                        |
| P1             | 15.93                   | 1.22                   |
| P2             | 13.39                   | 1.31                   |
| P3             | 15.04                   | 0.70                   |
| **Mean**       | **15.49a**              | **1.08a**              |
| Intercropping  |                         |                        |
| P1             | 11.74                   | 0.50                   |
| P2             | 15.49                   | 0.54                   |
| P3             | 10.05                   | 0.52                   |
| **Mean**       | **11.73b**              | **0.52b**              |

Notes: Numbers followed by different letters in the same column indicate different significantly based on the Duncan Multiple Range Test (DMRT) α = 5%

3.3. Alley cropping physiology

The intercrops affect corn physiology. The average value of chlorophyll a is 0.35 mg g⁻¹ in monoculture and intercropping treatments. The highest average value of chlorophyll b is 0.18 mg g⁻¹ (intercropping) and the lowest is 0.17 mg g⁻¹ (monoculture). The highest average stomata density was 131.35 (monoculture) and the lowest was 88.32 (intercropping) (Table 3). The chlorophyll content in the intercropping pattern treatment was higher than the monoculture treatment. This is probably caused by a decrease in the absorption of light intensity by the leaves. According to [7] the formation of more chlorophyll in shaded conditions is thought to be due to an imbalance in the formation of chlorophyll due to a reduction in radiation intensity.
### Table 3. Components of corn physiology

| Treatment   | Chlorophyll a (mg g⁻¹) | Chlorophyll b (mg g⁻¹) | Total chlorophyll (mg g⁻¹) | Stomata density |
|-------------|-------------------------|------------------------|---------------------------|-----------------|
| Corn        |                         |                        |                           |                 |
| Monoculture |                         |                        |                           |                 |
| P1          | 0.36a                   | 0.17a                  | 0.55b                     | 139.28a         |
| P2          | 0.32b                   | 0.18a                  | 0.46c                     | 117.20b         |
| P3          | 0.36a                   | 0.17a                  | 0.57a                     | 137.58a         |
| Mean        | **0.35**                | **0.17**               | **0.53**                  | **131.35**      |
| Intercropping |                     |                        |                           |                 |
| P1          | 0.32b                   | 0.18a                  | 0.48c                     | 71.34c          |
| P2          | 0.42a                   | 0.16a                  | 0.61a                     | 100.21b         |
| P3          | 0.32a                   | 0.19a                  | 0.57b                     | 93.42c          |
| Mean        | **0.35**                | **0.18**               | **0.55**                  | **88.32**       |

Notes: Numbers followed by different letters in the same column indicate different significantly based on the Duncan Multiple Range Test (DMRT) α = 5%

The intercrops affect soybean physiology. The highest average chlorophyll a value is 1.95 mg / g (monoculture) and the lowest is 1.86 mg / g (intercropping). The highest average chlorophyll b value is 0.73 mg / g (intercropping) and the lowest is 0.66 mg / g (monoculture). The highest average stomata density was 327.17 (intercropping) and the lowest was 266.49 (monoculture) (Table 4). The highest chlorophyll b content in intercropping crop treatment. According to [10] under low light stress conditions, soybeans with tolerant genotypes have higher chlorophyll b content. The response of chlorophyll to low light intensity in this case chlorophyll a and chlorophyll b is a complex component of the chloroplast peripheral antenna, the response is determined by the light conditions received as a form or mechanism of plant adaptation.

### Table 4. Components of soybean physiology

| Treatment   | Chlorophyll a (mg g⁻¹) | Chlorophyll b (mg g⁻¹) | Total chlorophyll (mg g⁻¹) | Stomata density |
|-------------|-------------------------|------------------------|---------------------------|-----------------|
| Soybean     |                         |                        |                           |                 |
| Monoculture |                         |                        |                           |                 |
| P1          | 2.04                    | 0.69                   | 2.73                      | 276.56a         |
| P2          | 1.93                    | 0.64                   | 2.57                      | 238.62b         |
| P3          | 1.88                    | 0.64                   | 2.52                      | 284.30a         |
| Mean        | **1.95a**               | **0.66**               | **2.61**                  | **266.49**      |
| Intercropping |                     |                        |                           |                 |
| P1          | 1.95                    | 0.78                   | 2.73                      | 327.73a         |
| P2          | 1.75                    | 0.66                   | 2.41                      | 326.44a         |
| P3          | 1.89                    | 0.75                   | 2.63                      | 327.33a         |
| Mean        | **1.86b**               | **0.73**               | **2.59**                  | **327.17**      |

Notes: Numbers followed by different letters in the same column indicate different significantly based on the Duncan Multiple Range Test (DMRT) α = 5%

3.4. Land equal ratio

Land use efficiency can be done by calculating the land equality ratio (NKL). The NKL calculation requires yields of monocultured and intercropped plants with two different types of plants in one area of land. Based on the results obtained NKL values of 1.14 for P1 treatment (recommended fertilizer), 1.38 for P2 treatment ((5 ton manure / ha + ½ recommended fertilizer) and 1.76 for P3 treatment (2.5 ton manure / ha + 1/2 fertilizer recommendation) (Table 5). This shows that the intercropping pattern in each fertilizer treatment is more efficient than monoculture in land use, so that the intercropping pattern can be recommended to oil palm farmers for application of intercropping in the replanting area of TBM-1 oil palm.
Table 5. Value of land equality ratio at each fertilizer treatment

| Treatment | Corn production (kg 50 m\(^2\)) | Soybean production (kg 50 m\(^2\)) | NKL |
|-----------|---------------------------------|-----------------------------------|-----|
|           | Monoculture | Intercropping | Monoculture | Intercropping |       |
| P1        | 33.60       | 24.67         | 6.09        | 2.51          | 1.14 |
| P2        | 26.59       | 25.87         | 6.52        | 2.66          | 1.38 |
| P3        | 25.57       | 25.98         | 3.50        | 2.59          | 1.76 |

4. Conclusion
The intercropping pattern in oil palm plantations can increase land productivity. The soybean intercropping patterns affect yield components. The P3 treatment (2.5 tons ha\(^{-1}\) manure + 1/2 recommended fertilizer) is the optimum fertilizer dosage for corn and soybean cultivation in the oil palm area (TBM-1) by intercropping based on the results of the land equality ratio of 1.76.

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