Utilize Open Space of Oil Palm (*Elaeis Guineensis* Jacq.) Plantation at Immature Stages for Growing Maize (*Zea Mays* L.) which is Applied Biofertilizer

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Abstract. Land optimizing in oil palm plantation could be conducted by adopting polyculture cropping system of maize grown under oil palm trees during immature stage (IS) due to wider plant distance. The maize growth depends on genetic and environmental condition such as soil fertility, in fact oil palm plantation is often located in marginal area which is lack of fertility like Inceptisol soil type in Jatinangor, so that it needs supply of biofertilizer to improve soil fertility. This study was to get interaction effect between biofertilizer application and kind of maize varieties that is giving best effect on growth and yield of maize under polyculture system of immature oil palm trees. The experiment was conducted from November 2017 to February 2018. The experimental design was using split plot which was biofertilizer as a main plot and biofertilizer application as a subplot. The result showed all varieties of maize gave significant effect on plant height, leaves number, and cob size. Independently, maize variety of DR6 gave the best effect on plant height at 4 and 6 WAP (weeks after planting), DR1 gave the best effect on leaves number at 4, 6, 8 WAP, and DR5 gave the best effect on cob size.

1. Introduction

Oil palm tree is one of important plantation crop due to its contribution to Indonesian national revenue in vegetable oil production. [1] reported oil palm is popular product in many industries, this is followed by increase in land use of oil palm plantation. For an example in 2016 the oil palm plantation field in Indonesia reached to 11,300,307 ha consisted of 22.74% of immature trees, 75.2% produced trees, and 2.06% unproduced trees [2].

Wider plant distance of palm oil i.e. 9 m x 9 m, there is open spaces between trees which could be grown another crop such as maize. [3] reported immature oil palm trees (0-12 months) there is 75% of open spaces among the trees, whereas at the later stage of immature trees (13-24 months) there is 60% of open spaces which is potential to adopt polyculture system in the oil palm plantation. Generally, under monoculture system of oil palm, the open space uses for growing soil cover crop such as legume, however under polyculture system, soil cover crop could be used edible crop so that the beneficial may increase rather than under monoculture system. Polyculture system gives some beneficial in economic and ecological sector [4]. There are some conditions that required for beneficial value under polyculture system namely the crops should be complements and or supplements each other’s, and the crops have economical value [5].

Maize is popular crop grown under polyculture system due to its beneficial both are economic and ecology, additionally, in Indonesia maize is main staple food besides rice [6]. National consumption of maize tends to be increases by increases people population and industries of food and feed. The consumption has reached to 22.08 million ton, however, the national production just reached to 20.31 million ton or less than its consumption. In other situation, the maize productivity of farmers is quite low reached 3-4 ton/ha, so that the polyculture system between oil palm tree and maize will be the best
alternative for increase maize production in the future. To do best practice in polyculture cropping system, selection of crop e.g. variety and application of fertilizer which is enriching soil fertility will be needed to get proper growth and development of crop under such condition. One of maize varieties that is developed by University Padjadjaran namely: DR Unpad known as improved variety with advantageous traits of shading tolerant will be proper to grown under polyculture system [7]. This study was to evaluate maize growth performance under oil palm tree in polyculture cropping system.

2. Materials and methods
The experiment was conducted at the experimental station Faculty of Agriculture Universitas Padjadjaran-Bandung from October 2017 to March 2018. Soil type was Inceptisol and the land location at the 752 m above sea level. Oil palm tree varieties of SEU Supreme were grown with plant distance of 8 m x 8 m at 1 year before growing maize in polyculture system in the land of 1 hectare. Seven maize varieties were used in this experiment consisted of DR-1, DR-2, DR-3, DR-4, DR-5, DR-6, and DR-7. These varieties are developed by Faculty of Agriculture Universitas Padjadjaran-Bandung. Maize was grown in between oil palm trees row with plant distance of 75 cm x 20 cm, so that it was 2 m distance to oil palm trees. Manure and inorganic fertilizer of NPK were added to the soil as a basic fertilizer in amount of 10 kg per plant of oil palm trees and 0.5 kg per plant of maize. All treatments in the experiments were designed to ensure that plants are not lack of nutrients at any point.

2.1. Biofertilizer application
Biofertilizer of Bion-up BION-UP (Pupuk Kujang Corp. INA), which contains living microbes, was applied to the soil in around root zone at two doses of application i.e. 0 and 150 ml per plant at 14, 21, and 28 days after sowing (DAS).

2.2. Measurements
Maize growth performance was measured for plant height, leaves number, yield and yield component. Another measurement was conducted for stomatal conductance (g_{s}) by using porometer (Decagon device Inc. US).

Stomatal conductance were measured at the 6 weeks after sow (WAS) to 2nd leaf from upper of maize. All measurement of gs were conducted on 4 leaves for each maize variety.

2.3. Yield and yield component measurement
Harvest of maize was conducted at the 13 WAS by collected cob then it was separated from grains to measure 100 grains weight.

2.4. Experimental design and statistical measurements
Experimental design was using split plot which was biofertilizer as a main plot and varieties as a subplot. There were 2 level of biofertilizer application i.e. b_{1}: application biofertilizer of 150 ml per plant; b_{2}: 0 application of biofertilizer. Varieties contained of 7 level i.e. c_{1}: DR-1; c_{2}: DR-2; c_{3}: DR-3; c_{4}: DR-4; c_{5}: DR-5; c_{6}: DR-6 and c_{7}: DR-7. In total there was 7 x 2 treatments and 3 replications. Significantly difference of data was analysed by LSD-Tukey tests, using SAS program.

3. Results and discussion
All measurement on plant such as plant height, leaf numbers, stomatal conductance and yield had shown no interaction between biofertilizer and variety of maize, even if there were significantly difference on the independent response of varieties and or biofertilizer application according to statistical analyses.

3.1. Plant height
At the 8 weeks after sowing, plant height of c_{6} was significantly higher than c_{2} and c_{3}, even if there were no significantly difference to DR 1, DR 4, DR 5, and DR 7 (Table 1).
Table 1. The effect of biofertilizer and varieties of maize on plant height at 4, 6, and 8 WAS

| Treatments | Average of Plant Height (cm) |
|------------|------------------------------|
|            | 4 WAS | 6 WAS | 8 WAS |
| Biofertilizer |      |        |       |
| b₁ = 150 ml/plant | 63.03 a | 115.89 a | 164.49 a |
| b₂ = 0 ml/plant | 59.81 a | 110.23 a | 163.98 a |
| Variety of maize |      |        |       |
| c₁ = DR 1 | 62.91 a | 114.56 a | 169.01 ab |
| c₂ = DR 2 | 66.22 a | 114.88 a | 157.72 b |
| c₃ = DR 3 | 59.59 a | 111.89 a | 153.65 b |
| c₄ = DR 4 | 59.75 a | 110.38 a | 163.59 ab |
| c₅ = DR 5 | 58.22 a | 111.41 a | 170.20 ab |
| c₆ = DR 6 | 64.83 a | 119.11 a | 176.09 a |
| c₇ = DR 7 | 58.44 a | 109.19 a | 159.38 ab |

Same letters in same column indicates no significantly difference according to LSD Tukey test 5%.

There was no significance interaction between biofertilizer and varieties of maize, it might be due to several reasons e.g., improper dose, idle of microbes, and or soil leaching during heavy rain. In the experiment, rainfall average had been recorded up to 275.8 mm/month, it is higher than an ideal rainfall for maize cultivation namely 85-200 mm/month [8]. Maize variety itself had shown significantly difference on plant height due to difference on the traits which responded to growth environment.

There was significantly difference on leaf number of maize at 4 and 6 WAS (Table 2), variety of c₁ was higher than c₄, however it was not significantly difference with other varieties. Plant height at 8 WAS showed no significantly difference among the variety.

Table 2. The effect of biofertilizer and varieties of maize on leaf number at 4, 6, and 8 WAS

| Treatments | Average of leaf number |
|------------|------------------------|
|            | 4 WAS | 6 MST | 4 WAS |
| Biofertilizer |      |        |       |
| b₁ = 150 ml/plant | 7.02 a | 9.29 a | 10.31 a |
| b₂ = 0 ml/plant | 6.93 a | 9.25 a | 10.19 a |
| Variety of maize |      |        |       |
| c₁ = DR 1 | 7.44 a | 9.88 a | 10.58 a |
| c₂ = DR 2 | 6.94 ab | 9.12 ab | 10.00 a |
| c₃ = DR 3 | 7.00 ab | 8.88 ab | 10.04 a |
| c₄ = DR 4 | 6.50 b | 8.81 b | 10.08 a |
| c₅ = DR 5 | 7.06 ab | 9.44 ab | 10.25 a |
| c₆ = DR 6 | 7.19 ab | 9.25 ab | 10.54 a |
| c₇ = DR 7 | 6.69 ab | 9.50 ab | 10.25 a |

*Same letters in same column indicates no significantly difference according to LSD Tukey test 5%.*
3.2. Leaf number
DR 4 has lowest leaf number, it is possible due to its traits of higher in yield potential compared to DR 1 (Table 4), too many leaves will make inefficient on photosynthesis distribution so that will affect on yield [9]. High in leaf number is usually followed by high in yield, however, there is ideal number of leaf which could be increase efficiency of photosynthesis. This result is needed to be clarified furthermore how many leaf ideally could improve high efficiency of yield. Application of Bion up did not improve leaf number due to other study on biofertilizer of Bion up showed the application of biofertilizer could improve leaf canopy, plant height and yield [10].

Table 3. The effect of biofertilizer and varieties of maize on stomatal conductance at 8 WAS

| Treatments       | Average Stomatal Conductance (mmol/m²/s) |
|------------------|------------------------------------------|
| Biofertilizer    |                                          |
| b₁ = 150 ml/plant| 394.58 a                                 |
| b₂ = 0 ml/plant  | 354.00 a                                 |
| Variety          |                                          |
| c₁ = DR 1        | 307.23 a                                 |
| c₂ = DR 2        | 435.14 a                                 |
| c₃ = DR 3        | 289.38 a                                 |
| c₄ = DR 4        | 339.43 a                                 |
| c₅ = DR 5        | 382.56 a                                 |
| c₆ = DR 6        | 449.18 a                                 |
| c₇ = DR 7        | 417.14 a                                 |

Same letters in same column indicates no significantly difference according to Tukey test 5%.

3.3. Yield and yield component
Cob length of DR 5 was a significantly longer than DR 1, DR 2, and DR 4, however, it was not significant difference to DR 3, DR 6, and DR 7 (Table 5).

Table 4. Yield potential of maize variety of DR

| Yield potential of maize (ton/ha) |
|-----------------------------------|
| DR 1  | 3.16 |
| DR 2  | 2.47 |
| DR 3  | 1.45 |
| DR 4  | 4.63 |
| DR 5  | 2.76 |
| DR 6  | 6.45 |
| DR 7  | 4.91 |

Source: Description of DR maize [7]

3.4. Stomatal conductance (gₛ)
Application biofertilizer did not give significantly difference on stomatal conductance among maize varieties (Table 3), even though variety of DR6 showed a tendency of higher in gs compared to other, it might be due to DR6 has a highest yield potential among six varieties, conversely, DR 3 has tendency a lowest in gs among the varieties due to lowest in yield potential among six varieties (Table 4), even if
this result was not significant difference. Stomatal conductance could be explains plant photosynthetic response due to its role on CO\textsubscript{2} diffuse on leaf. High in gs means high in CO\textsubscript{2} to diffuse in the leaf so that it will high in photosynthesis activity as well. Value of gs was more than 250 mmol m\textsuperscript{-2} s\textsuperscript{-1} indicates there were no stress on plants.

Table 5. The effect of biofertilizer and varieties of maize on cob length and diameter at 13 WAS

| Treatments             | Cob length | Cob diameter |
|------------------------|------------|--------------|
| Biofertilizer          |            |              |
| b\textsubscript{1} = 150 ml/plant | 18.44 a    | 4.22 a       |
| b\textsubscript{2} = 0 ml/plant  | 18.86 a    | 4.23 a       |
| Variety of maize       |            |              |
| c\textsubscript{1} = DR 1  | 17.91 b    | 4.21 a       |
| c\textsubscript{2} = DR 2  | 17.92 b    | 4.16 a       |
| c\textsubscript{3} = DR 3  | 19.15 ab   | 4.12 a       |
| c\textsubscript{4} = DR 4  | 18.16 b    | 4.34 a       |
| c\textsubscript{5} = DR 5  | 20.18 a    | 4.19 a       |
| c\textsubscript{6} = DR 6  | 19.03 ab   | 4.30 a       |
| c\textsubscript{7} = DR 7  | 18.30 ab   | 4.27 a       |

Same letters in same column indicates no significantly difference according to LSD Tukey test 5%.

Cob length effects on seed number, consequently, plant needs higher energy for producing more grain, it is well known balance of sink and source could be result in yield. Cob length if it does not followed by high in source i.e. photosynthetic leaf will show in low yield [11], this could be seen at the longer cob of DR 3 and DR 5 did not correlated with high yield such as in DR 6 (Table 4). In facts, genetic diversity of maize varieties and their interaction effect on yield [12].

3.5. A hundred grains weight

Table 6. The effect of biofertilizer and varieties of maize on 100 grains per cob (g) at 13 WAS

| Treatments            | Average 100 grains |
|-----------------------|--------------------|
| Biofertilizer         |                    |
| b\textsubscript{1} = 150 ml/plant | 17.24 a           |
| b\textsubscript{2} = 0 ml/plant  | 16.46 a           |
| Variety              |                    |
| c\textsubscript{1} = DR 1  | 15.32 a           |
| c\textsubscript{2} = DR 2  | 16.77 a           |
| c\textsubscript{3} = DR 3  | 16.24 a           |
| c\textsubscript{4} = DR 4  | 17.27 a           |
| c\textsubscript{5} = DR 5  | 17.86 a           |
| c\textsubscript{6} = DR 6  | 16.93 a           |
| c\textsubscript{7} = DR 7  | 17.54 a           |

Same letters in same column indicates no significantly difference according to Tukey test 5%.
There were no significantly differences on a hundred grains among DR 1 – DR 7. A hundred grain was ranged from 15.32 g of DR 1 to 17.86 g of DR 5 (Table 6). Grain weight of maize is affected by temperature, proper temperature for maize growth and development ranged from 18 °C to 27 °C. In this experiment temperature average was 23.3 °C.

Further research is needed to clarify best dose of biofertilizer at some levels to get clearer effect on maize growth and development under oil palm polyculture cropping system. Maize could be grew at the immature stage of oil palm with a productivity without reduce its productivity.

4. Conclusion
Maize cultivation under polyculture system at the immature stage of oil palm tree could be done to increase land utilities without any disadvantages of plant growth and yield.

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