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The Efficiency of Inorganic Fertilizer Use on Potential Leguminoceae Cover Crop Species at the Oil Palm Plantation of Dharmasraya Regency

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Abstract **Original Research Article**

The regular use of inorganic fertilizers on oil palm plantations has a lot of negative effects; hence the most effective species of *Leguminoceae Cover Crop* (LCC) is needed to reduce the use of inorganic fertilizers. The purpose of this research is to find out which LCC species is best used in oil palm plantations at Dharmasraya Regency. The methods used in this research were observing seed germination, measuring biomass treatment using destructive methods, and measuring soil nitrogen levels using the *kjeldahl* method. The results showed that based on seed germination aspect, there was no significant difference in each treatment ($p > 0.05$), while based on the amount of biomass, *Mucuna bracteata* (3,60 gr) had the highest level of effectiveness. Analysis of soil Nitrogen content showed that the treatment of *Mucuna bracteata* (0,22%) and *Centrosema pubescens* (0,21%) were effective to use as cover crops. The conclusion obtained is that based on seed germination, there is no effective species, and for the amount of biomass, *Mucuna bracteata* has the highest effectiveness, while based on soil nitrogen levels, *Mucuna bracteata* and *Centrosema pubescens* species are effective to use as cover crops. Thus, the most effective species of Leguminoceae Cover Crop on oil palm plantations in Dharmasraya Regency is *Mucuna bracteata* species.

Keywords: Biomass, *Centrosema pubescens*, kjeldahl method, seed germination, nitrogen, *Mucuna bracteata*.

INTRODUCTION

Oil palm (Elaeis guineensis Jacq) is one of the plantation crops in Indonesia that has high economic value, making it one of the non-oil and gas foreign exchange sources in Indonesia. This tropical plant claims the largest plantation area, where in 2015 the area of oil palm plantations reached 4,575,101 ha with palm oil production of 10,668,425 tons [1]. These areas of oil palm plantations in Indonesia continues to increase as years go by, one of which is the area in Dharmasraya regency. Dharmasraya is regency whose area of oil palm plantations is largest in West Sumatra Province, second only to West Pasaman Regency. The area of oil palm plantations in Dharmasraya Regency in 2015 reached 72,934 ha with production of 1,290,714 tons, and the number had increased in 2016 to 73,106 ha [2]. In order for these oil palm plants to grow well and have optimal productive potential, they need appropriate climatic conditions, soil types, and other growing conditions such as altitude and rainfall. Oil palm plants need large amounts of nutrients for vegetative and generative growth, as well as to get high production [3]. One of the efforts conducted by oil palm plantation owners in improving soil structure and increasing soil fertility is by conducting routine fertilization. According to [4] the types of fertilizers commonly used are inorganic fertilizers such as Urea (CO (NH2) 2), RP (Ca (PO4) 2), MOP (KCl), HGFB (B2O3), Zn (ZnSO4.H2O), Cu (CuSO4.H2O), Palmo (14-8-21-2), and Kieserit (MgSO4.H2O).

Regular use of inorganic fertilizers on oil palm plantations causes a lot of negative effects, According to [5] the amount of inorganic fertilizers (N, P, and K) given to oil palm plants in West Sumatra Province in 2014 was 337,544,932 kg, while the total of inorganic fertilizers absorbed by plants only counted to 147,395,219.40 kg; the total inorganic fertilizer wasted from oil palm plantations in West Sumatra Province during 2014 was 180,149,712.60 kg. Environmental losses caused by those wasted fertilizers, which were washed away and carried away by erosion and run off into the river and eventually the sea, resulting in environmental damage such as the death of biota in said rivers and seas [6]. According to [7] costs incurred for fertilization are quite high, ranging from 40-60% of total plant maintenance costs, or around 24% of total production costs.

The negative effects of regular fertilization carried out on oil palm plantations can be reduced by returning organic matter to the soil through the use of organic fertilizer while simultaneously reducing the dose of inorganic fertilizer [8]. One option is by planting crops from the family of leguminoceae as a cover crop (ground cover) under the area or the base of oil palm plantations which are usually referred to as LCC species. According to [9] Leguminoceae Cover Crop (LCC) application is the right way to optimize the potentiall of land with environmental-friendly principles. The results of various analysis showed that LCC cover crops significantly affected the organic matter content, volume weight, and total soil pore space. This happens because brown waste on the ground surface produced by ground cover crops of beans will be decomposed rapidly by soil microorganisms, causing the amount of organic matter to increase [10].

Due to the great benefits obtained from planting crops from the leguminoceae family in the plantation area, it is needed to find out the right type of leguminoceae to plant, because this is influential to the success of land improvement. The parameters that can be used to determine the effectiveness of LCC species are seed germination, biomass of Leguminoceae Cover Crop (LCC) species, and the amount of soil nitrogen content in the oil palm plantation before and after planting cover crops. Therefore it is necessary to conduct research on the efficiency of fertilizer use using potential species of leguminoceae cover crop (LCC) in the oil palm plantation of Dharmasraya Regency. According to [9] there are several types of LCC that are most often used on oil palm plantations based on the characteristics that have been mentioned to be introduced by *Mucuna bracteata*, *Centrosema pubescens*, *Calopogonium mucunoides*, *Pueraria javanica and Calopogonium caeruleum*.

The purpose of this research is to determine which Leguminoceae Cover Crop (LCC) species were the most effective as cover crops in Dharmasraya Regency plantations based on seed germination, biomass produced with destructive method and based on soil nitrogen sources with kjeldahl method.

MATERIALS AND METHOD

The research was conducted for 3 months in the Department of Biology, Faculty of Mathematics and Natural Sciences, Andalas University, Padang, Indonesia. In the form of plant maintenance, measurement of Nitrogen content and biomass measurements of the LCC species. Soil sample was taken at the oil palm plantation in Dharmasraya Regency, West Sumatra Province. the treatment used in research are MB (Mucuna bracteata), CP (Centrosema pubescens), CM (Calopogonium mucunoides), PJ (Pueraria javanica), CC (Calopogonium caeruleum), NPK (NPK Fertilizer) and K (Control). Materials use in research are polybag, water, H2SO4, aquades, 250 gr selenium, NaOH, methyl red, bromcresol green, and NPK fertilizer.

To Measuring Seed Germination The seeds of Mb (Mucuna bracteata), Cp (Centrosema pubescens), Cm (Calopogonium mucunoides), Pj (Pueraria javanica) and Cc (Calopogonium caeruleum) were taken as many as 50 seeds with 4 replicates for each LCC species, germinated in polybags with the weight of the soil of 3 Kg each and with a planting depth of 0.5 cm. Those seeds were germinated for 8 days, with every day of the seeds germinating were observed and the number of normal sprouts were counted. The formula to calculate the percentage of germination power is calculated based on the [11] formula as follows:

$$\%DB = \frac{\Sigma KN}{\Sigma TB} X\, 100\%$$

% DB = percentage of germination
Σ KN = number of normal sprouts
Σ TB = total amount of germinated seeds

To Measuring Biomass of LCC Species Retrieval of LCC species was done using destructive methods (taking whole parts of the plant), then the plant was separated between the roots (plant organs in the soil) and stems (plant organs on the surface of the soil). Each LCC species was taken and weighed to get a wet weight (BB). All of these species were taken to the laboratory to be dried in an oven at 80° C for 48 hours in order to obtain dry weight (BK). Then, the wet weight and dry weight of the LCC species can be used to predict biomass. To find out soil cover crops biomass, the following biomass measurement formula SNI was used:

$$BKt = \frac{BKc}{BBc} x\ BBt$$

BKt = Total Dry Weight (g)
BBt = Total Wet Weight (g)
BBc = Wet Weight sample (g)
BKc = Dry Weight sample (g)

To Measuring Soil Nitrogen Level, use kjeldahl method. take 0.2–0.5 gr of 0.5 mm soil samples were weighed and put into boiling flask, 1 gram selenium and 5 ml concentrated sulfuric acid were added, destructed to 350 ° C (about 3-4 hours). The destruction was complete when white steam emerged and clear extract was obtained. The already cold extract was then diluted with distilled water up to 50 ml, shaken until homogeneous, and left for 1 x 24 hours for the particles to settle. The boiling flask was transferred to a distillation device, a prepared erlenmeyer containing 15 ml of 4% boric acid, added with 3 drops of indicator, then connected with a distillation device. 40% NaOH as much as 20 ml into was added into the boiling flask and immediately closed, distillated until the container volume reaches 50-75 ml (green-colored), then the distillate was titrated with H_2SO_4 0.05N to pink-colored, while the volume of titration and volume blank were noted.

$$\text{Level N (\%)} = ((\text{titration volume} - \text{blank volume}) \times N \times 14 \times 100)) \times KKA / (\text{mg sample})$$

N = normality of H_2SO_4 (0.05N) standard solution
14 = N atomic weight
KKA = water level correction factor

Obtained data of seed germination, biomass of LCC species, and soil nitrogen levels were analyzed statistically using variance analysis with linear models. Data that had a significant effect on the analysis of variance were further tested using a Duncan Multiple Range Test (DMRT) at the level of significance of 5%. The final data obtained in the form of species that have the highest seed germination, biomass, and soil nitrogen content are the most effective species used as a species of land cover in the oil palm plantation of Dharmasraya Regency.

RESULT AND DISCUSSION

Table-1: Percentage of Leguminoceae Cover Crop (LCC) Species Seed Germination

Treatment	Replication			
	1	2	3	4
K	0 a	0 a	0 a	0 a
MB	0,14 a	0,14 a	0,16 a	0,14 a
CP	0,12 a	0,14 a	0,16 a	0,14 a
PJ	0,18 a	0,18 a	0,20 a	0,18 a
CM	0,12 a	0,12 a	0,10 a	0,12 a
CC	0,12 a	0,12 a	0,12 a	0,10 a

Remarks: The numbers followed by letters that are not the same in the column show are significantly different according to the Duncan Test at the test level of 5%

The results of the statistical analysis (table 1) show that there were no significant differences ($p > 0.05$) on seed germination of each treatment of K, MB, CP, PJ, CM and CC. In other words, based on the seed germination, each LCC species is relatively the same, so other parameters can should be used to determine the most effective species as cover crops in Dharmasraya Regency oil palm plantations, such as seed availability and seed price.

Seed Germination in the K, MB, CP, PJ, CM and CC treatments for eight days of observation, ranged from 10-20%. It was classified as low compared to other leguminoceae sprouts, as shown in the research of de [12] that sprout power untreated leguminoceae *Macroptilium atropurpureum* seeds (control variable) showed seed germination of 44%. Low germination might be caused by several factors, such as dormancy of leguminoceae seeds, hard seeds, poor storage conditions, and seed quality. Efforts that can be done to overcome those shortcomings are explained in the research of [13] which stated that cutting seed shells was the best treatment that can increase the seed germination of *Mucuna bracteata*, as well as giving 300 ppm GA_3 for the better treatment of seed germination, while the best combination was by cutting of the seed shell and the administration of 300 ppm GA_3 and the treatment of rubbing by using sandpaper. Factor causing low seed germination during the research was the attack of pathogens to the seeds in the form of fungi, so that the seeds rot and were difficult to germinate. This was in accordance with the opinion of [14] which stated that seed borne diseases were caused mainly by pathogens of fungai species, bacteria, and viruses originating from the field.

Germination media also influenced the low sprouting power of LCC species. The germination media used in this research was relatively infertile oil palm plantation, making the germination process did not run optimally. At the time of application on the plantation, the seeds of the LCC species should be planted in media that are relatively more fertile so that they can increase the seed germination power. This is also explained in the study of [15] which stated that germination media greatly affected the physiological quality of the seed tested because germination media was an important factor that supports the germination process as it supplied the water needed during the germination process. In addition, germination media was also used for satisfying everything needed by seeds, so that the seeds could grow optimally.

Table-2: Amount of Leguminoceae Cover Crop (LCC) Species Biomass for Plant Organs over the Surface and Plant Organs under the Surface after 2 Months of Planting

Treatment	Replicatiom				Average
	1	2	3	4	
Organs above the ground					
K	0,00	0,00	0,00	0,00	0,00 a
MB	3,82	3,44	4,08	3,04	3,60 c
CP	1,45	0,98	1,56	1,36	1,34 b
PJ	0,98	1,63	1,22	1,03	1,22 b
CM	1,72	2,29	2,28	1,45	1,94 b
CC	1,91	1,38	1,15	1,44	1,47 b
Underground organs					
K	0,00	0,00	0,00	0,00	0,00 a
MB	3,07	3,08	3,71	4,56	3,61 d
CP	1,57	0,55	1,05	1,24	1,10 b
PJ	1,09	1,14	1,14	0,76	1,03 b
CM	2,24	2,10	3,56	1,99	2,47 c
CC	1,49	0,97	1,05	1,36	1,22 b

Remarks: The numbers followed by letters that are not the same in the column show are significantly different according to the Duncan Test at the test level of 5%

The analysis of the amount of biomass revealed that the amount of organic matter contained in the body of the plant. Those above-ground plant organs biomass (stems, branches and leaves) in each treatment K, MB, CP, PJ, CM and CC showed that there were significant differences ($p < 0.05$). The treatment of K, CP, PJ, CC and CM showed relatively the same level of effectiveness, while the treatment of MB was relatively different. Based on the average obtained from the treatment, MB (*Mucuna bracteata*) with an average biomass of 3.60 gr had the highest level of effectiveness as a cover crop in the oil palm plantation of Dharmasraya Regency. The reason was that during the research, it was seen that the growth of *Mucuna bracteata* species was faster than other species. Moreover, the morphology of the MB organs was also greater compared to those of other species, causing biomass of the *Mucuna bracteata* species to be high. According to [10] research on *Mucuna* sp., different results from other species were obtained. The high content of soil organic matter in the treatment of *Mucuna* sp. was due to the rapid growth of *Mucuna* sp. compared to other LCC species.

The amount of underground organ biomass (root) (table 2) in each treatment K, MB, CP, PJ, CM and CC also showed a significant difference ($p < 0.05$). The CP, PJ and CC treatments were relatively the same, while the CM and MB treatments were relatively different. Based on the average, it was obtained that the treatment of MB (3.61 g) has a higher level of effectiveness than treatment of CM (2.47 g). According to [16] MB or *Mucuna bracteta* species were able to form roots that can penetrate into the soil up to 2-3 m; the root growth rate was quite high. At the age of over three years, the root could reach a depth of 3 m. Oil palm plantation production at locations using *Mucuna bracteata* as ground cover was higher than in locations using conventional ground cover. Relatively high fertility and maintained humidity were thought to be the main causes of plant productivity in the *Mucuna bracteata* soil covered area. Brown waste from biomass of *Mucuna bracteata* soil cover which was very large is an important source of nutrients for increasing soil fertility [17].

According to [18], production of high biomass from cover crops will correlate positively with the return of nutrients into the soil in improving soil fertility. Producing high organic matter will be very useful for areas with low organic matter and often experience drought such as in oil palm plantations. Thus, *Mucuna bracteata* which has the highest above-ground and below-ground biomass is effective to use as a ground cover species in oil palm plantations.

Table-3: N Soil Levels (%) after 2 Months of Leguminoceae Cover Crop (LCC) Species Planting and Provision of NPK Fertilizers

Perlakuan	Ulangan				Rataan
	1	2	3	4	
K	0,11	0,11	0,10	0,12	0,11 a
MB	0,21	0,23	0,23	0,21	0,22 b
CP	0,22	0,20	0,22	0,21	0,21 b
PJ	0,15	0,15	0,14	0,13	0,14 a
CM	0,16	0,15	0,14	0,16	0,15 a
CC	0,19	0,19	0,20	0,18	0,19 a
NPK	0,24	0,24	0,24	0,25	0,24 b

Remarks: The numbers followed by letters that are not the same in the column show significantly different based on nitrogen levels [19]

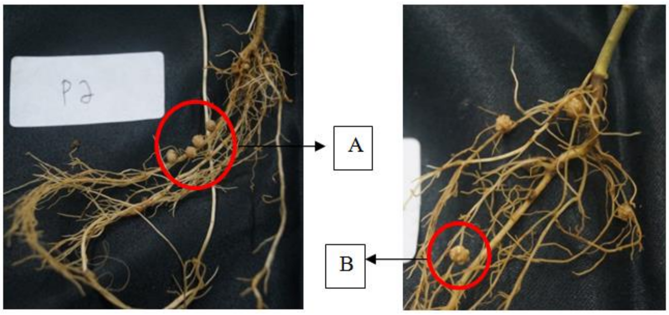

Fig-1: (a) Root nodule of *Pureira javanica*, (b) Root nodule of *Centrosema pubescens*

Based on table 3, it can be seen that the treatment of K, MB, CP, PJ, CM, CC and NPK has a significant effect on the soil nitrogen content of the oil palm plantation in Dharmasraya Regency ($p < 0.05$). The treatment of K, PJ, CM and CC had low levels of soil nitrogen content, whereas MB, CP and NPK had moderate levels. According to [19] soil nitrogen levels are said to be Very Low if N (%) <0.10, Low if N (%) ranges from 0.10-0.20, Medium if N (%) ranges from 0.21-0.50, High if N (%) 0.51-0.75, Very High if N (%)> 0.75.

The cultivation of PJ, CM and CC species all had the same low soil nitrogen content category as the control treatment. This explains that planting PJ, CM and CC species had no significant effect on increasing soil nitrogen content, so they were not effective to use as cover crops on the oil palm plantation in Dharmasraya Regency. The treatment of MB and CP produced soil nitrogen with a medium category that was the same as NPK treatment; this explained that the planting of MB species and CP had a significant effect in increasing soil nitrogen levels. So, the treatment of MB (*Mucuna bracteata*) and CP (*Centrosema pubescens*) is effective to use as cover crop and as organic fertilizer in the oil palm plantation in Dharmasraya Regency. Due to low level of soil nitrogen produced by MB and CP species, other factors such as seed availability and seed prices can be used to determine the most effective species.

The increase of soil content from low criteria to medium criteria on MB (*Mucuna bracteata*) and CP (*Centrosema pubescens*) occurred due to increased N content compared to pre-treatment soil, this was due to the presence of root nodules (Figure 2) found in leguminoceae, where these root nodules were able to bind N in big amount. In the research of [20] it was mentioned that changes in the quality of oil palm plantation land after planting LCC include the content of organic C in the soil after planting LCC can be classified as low to moderate criteria, where the C-organic content in the soil is closely related to organic matter in the ground. The N-total content in the soil after being planted with LCC was classified as a medium criterion, the increase in N content compared to the initial soil was due to bacterial symbiosis found in the root nodules of legume plants, where large amounts of bacteria in the root nodules were able to bind N from the air. The K content after being planted with LCC has experienced an increase from low to moderate criteria in the area planted with LCC. Whereas in the research of [16], it was explained that the planting of *Mucuna bracteata* species produced nutritional values in areas with a shade of 8.7 tons (equivalent to 263 kg NPKMg with 75-83% N) and in open areas as much as 19.6 tons (equivalent to 531 kg NPKMg with 75-83% N).

CONCLUSION AND SUGGESTION

Based on seed germination on five species of LCC for eight days of observation, the results ranged from 10-20%. The results of statistical analysis showed that there were no significant differences ($p > 0.05$). Analysis of the amount of biomass in each treatment showed that there was a significant difference ($p < 0.05$). The treatment of CP, PJ and CC tended to be the same in the level of effectiveness, while species CM and MB tended to be different. Based on the average obtained, the MB (3, 60 gr) treatment had the highest level of effectiveness. Analysis of soil nitrogen content showed that the treatment given had a significant effect ($p < 0.05$). The treatment of MB (0, 22%) and CP (0, 21%) approached the NPK Nitrogen Level in the medium category, thus the treatment of MB and CP was effective to use as a cover crop and as organic fertilizer in the oil palm plantation in the Dharmasraya Regency.

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