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The Production and Quality of Mott Grass (Pennisetum Purpureum CV. Mott) that Intercropped with Legume in the First Pruning

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Abstract

One of important factors in improving the production of ruminants is the availability of qualified green fodder throughout the year. The qualified green fodder mainly consists of grass as the source of energy, and legume as the source of protein. In Indonesia, especially in Bali, the livestocks' farmers still utilize grasses from field as their livestocks' fodder, due to the lack of special lands to plant grasses. Therefore, an intercropping between grass and legume is considered to be necessary. Furthermore, fertilization is also considered to be significant to produce an optimum production. Fertilization that could be implemented by farmers without any additional cost is by using Compost and Biourine. This research was conducted from November 2015 to February 2016. The researchers applied Randomized Block Design (RBD) with factorial pattern 3 x 2, in which 3 factors of Plant's types: Mott Grass (Pennisetum purpureum cv. Mott) without legume (G1); Mott Grass (Pennisetum purpureum cv. Mott) with Centro Legume (G2); Mott Grass (Pennisetum purpureum cv. Mott) with Calopo Legume (G3), and 2 factors of fertilizer's types: Compost (C) and Biourine (B). Each combination of treatment was repeated 3 times. Th results of the research showed significant difference for parameters Total Production of Fresh and Dry forage ($P<0.01$), Number of Tillers and Number of Leaves ($P<0.01$), and Botanical Composition of the first pruning. Meanwhile, for parameter Plants' Height did not show significant difference ($P>0.05$). The Plant's types factor showed significant influence ($P<0.05$) toward the crude protein content of the Mott Grass.

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1. Introduction

Background of the Study

The availability of forage is one of constraints which faced by farmers, especially in the dry season. The utilization of unfertile lands to grow fodder crops is considered to be important, since there have not been any land that specialy utilized as fodder crops. Thousand hectares of vacant land in Indonesia is a very potential land if merely could be managed effectively. Fodder is an important factor for ruminants' growth and productivity, since most of ruminants' fodder come from grass and legume. Legumes are high-quality forage and mainstay for tropical ranch as the source of soil nitrogen (Anonim, 1999). For livestock enterprises, the composition of green fodder in the ration could reach to 90%. The generous production cost of fodder would ensure the success of the business. However, the effort to reduce the production cost meets some constraints, such as the limited land and the fertilizer costs.

Intercropping of grass and legume is one of the ways to increase the production of green fodder while decreasing the nitrogen fertilizer input. The intercropping needs a proper management to set the kind of legume and grass that should be intercropped. Mott Dwarf Elephant Grass or Mott Grass (*Pennisetum purpureum* cv. Mott) is one of new developed varieties of Elephant Grass, which has shorter size than the common Elephant Grass. The grass could grow on various kinds of soil, including alkali soil, and would be very responsive to fertilization.

Generally, the weaknesses of Mott Grass are depleting the soil's nutrients fast and getting aging rapidly that declining its nutrient content. Therefore, the intercropping with legume is much suggested. The intercropping between Mott Grass and legume is seen to be one of the efforts to increase the production and quality of green fodder and to improve the soil fertility (Chullank, 2012).

Legumes are plants of the pea or bean family, which are good for fodder due to the high protein content. The green legumes, whether herbs or trees, are green forages that contain higher nutrient content, compared to the common grass. The high crude protein content is also the source of vitamins and minerals.

There are many potential types of green forage to support the need of green fodder stock, such as legume from genus centrocema. *Centrocema pubescens* is a legume that resistant in both dry and wet lands (Ibrahim, 1995). Reksohadiprodjo (1994) stated, *Centrocema pubescens* could be intercropped with grass and showed better growth with *Panicum maximum*, *Melinis minutiflora*, and *Cynodon plectostachyon*.

On the other hand, *Calopogonium* is considered to be one of cover crops that could be utilized in tea farm and forestry, or even for forage. The plant is used to utilize to suppress weeds and increase soil fertility. *Calopogonium mucunoides* comes from Southern America with perennial, vine and twining characteristics, which could be planted in others tropical regions as erosion control plant, cover crop, weeds control plant, and intercrop. The plant is good and liked by livestocks, and could grow well on dry acid soil.

The cultivation of green fodder on fertile soil would produce better result compared to the cultivation of ciritical soil. The success of green fodder's cultivation should be supported by both ideal soil and weather (Sumarsono, 2005). Fertile soil is needed for the growth and development of green fodder, since the greens are a primary fodder for ruminants. Proper fertilization in terms of time and dosage is considered to be effective to intensify the intercropping, in order to increase the result and quality of both grass and legume (Centro and Calopo).

Composting is one of fertilization that could optimize the growth of both crops. Supported by fertile soil, the crops could absorb nutrients easily through their roots. Composting is good also to overcome unfertile soil. The utilization of compost as the source of nutrients is one of free-chemical program, though compost is considered to be lack of nutrients compared to chemical fertilization. Based on the explanation above, the researchers considered that a research is needed to investigate how is the growth of intercropping between grass and legume which is supported by compost and bio-urine.

Problems of the Study

Based on the background of the study, the researchers formulated the problem of the study as follows:

1) Is there any interaction between the Plant's type and the Fertilizer's type toward the production and quality of Mott Grass (*Pennisetum purpureum* cv. Mott).
2) Is there any influence of the Plant's type toward the production and quality of Mott Grass (*Pennisetum purpureum* cv. Mott).
3) Is there any influence of the Fertilizer's type toward the production and quality of Mott Grass (*Pennisetum purpureum* cv. Mott).

Objective of the Study

The objective of the study was to investigate the production and quality of Mott Grass (*Pennisetum purpureum* cv. Mott), which was intercropped with Centro and Calopo Legumes.

2. Materials and Methods

2.1 Design of Experiment

The field experiment was implemented Randomized Block Design (RBD) with factorial pattern 3 x 2, in which 3 treatments of Plant's type (Factor A) and 2 treatments of Fertilizer's type (Factor B). The Factor A (Plant's type), namely G_1 (merely Mott Grass), G_2 (Mott Grass + Centro Legume) and G_3 (Mott Grass + Calopo Legume). Meanwhile, Factor B (Fertilizer's type), namely B (Biourine) and C (Compost).

2.2 Place and Time of the Study

The study was conducted at the Experimental Station of Faculty of Agriculture in Warmadewa University, Denpasar. The study was conducted from 24 November 2015 to 3 February 2016 (70 days).

2.3 Research Execution

a) Preparation of Block and Cultivation

Land that has been processed was formed into blocks. Then the researchers did randomization to each block and selected identical seedlings for each block before planting the seedlings. Further, the selected Mott seedlings were planted to the blocks with a depth of one segment, while the legume seedlings (Centro and Calopo) were planted based on the predetermined depth. The land for cultivation has a length of 1.2 m and a width of 1.6 m. 3 types of plant, namely Mott Grass, Calopo, and Centro were planted to each block with a distance of 70cm between grasses, and 40cm between grass and legume. The planting process was followed by watering process regularly.

b) Fertilization

Fertilizers that were used for this research namely Compost and Biourine. The dosage of Compost was 3 tons/ha or 576 g/block. Meanwhile, the dosage of Biourine was 450 l/ha or 86,4 ml/block. The fertilization was done two times with a half of the determined dosage for each fertilization period. The first period was done a week before the planting process and the second period was done after 2 weeks of the planting process. The Compost was given for each block by showing it on the soil surface and mixing both of elements evenly. On the other hand, the Biourine was given by diluting it into water and watering the mixture to the plants.

c) Plants' Maintenance

The plants' maintenance was done from the planting process of the seedlings to the harvest period. The maintenance would be explained as follows:

1) Watering

At the beginning of growth, Mott Grass and legumes needed sufficient water. Therefore, watering was done every day in the morning and evening or based on the weather and the soil condition. While watering the plants, the soil should not be too muddy, which might lead to root rot.

2) Weeding
During the growth of the plants, weeding process was done by pulling the weeds by hands or hoe, without damaging the plants' root. This process was indirectly loosening the soil.
3) Harvest
The harvest period for Mott Grass, Centro, and Calopo was done after the plants were 60-70 days or before the legumes were blooming.

2.4 Observed Parameters

a) The Growth of Mott Grass, namely: (a) Plants' Height: The observations of Plants' Height were made at the grass samples randomly, since 3 weeks after the planting process. Further measurements were done once a week until the plants reached their maximum heights. The Plants' Height was measured from the soil surface to the highest tip of the plants' buds; (b) Number of Leaves: The researchers counted the Number of Leaves based on leaves that have been fully opened with green color. The observations were done once a week started from 3 weeks after the planting process until the maximum number was met; (c) Number of Tillers, The researchers counted the tillers on the parent plants, in which the researchers merely considered those that have produced fully-bloomed leaves.
b) Botanical Composition
After the plants were 3 months, the researchers did pruning process of 10 cm from the soil surface. Each cut was weighed and separated among the grass, legumes, and weeds, to investigate the botanical composition.
c) Total Fresh Production and Total Dry Weight
The Total Fresh Production could be counted by weighing the total crop production per ha. Meanwhile, the Total Dry Weight could be counted by multiplying the Total Fresh Production with the dry material content.
d) The Quality of Mott Grass's Nutrient Content, namely:
The crude Protein content and the crude fiber content of Mott Grass.

2.5 Data Analysis

The data which were obtained from the results of the study were analyzed by using Analysis of Variant. If there was a significantly different ($P<0.05$) among the treatments, so the analysis should be continued with Multiple Range Test by Duncan (Steel & Torrie, 1989).

3. Results and Discussions

3.1 Growth

The interaction between the Plant's types (Factor A) and the Fertilizer's types (Factor B) toward the growth of Mott Grass showed insignificant influence ($P>0.05$). The growth of Mott Grass which was planted with Legumes (Factor A) showed the significant different result ($P<0.01$) for parameters Number of Leaves and Number of Tillers. Meanwhile, for parameter Plants' height showed the significant different result (table 1). Meanwhile, the Factor B (Fertilizer's types) did not show significant influence ($P>0.05$) toward all of the growth parameters.

Table 1
The influence of type of plant toward the growth of mott grass
(*Pennisetum purpureum* Cv. Mott)

Parameter	Treatment		
	G_1	G_2	G_3

Number of Leaves (strand/clump)	119.5[a]	158.33[b]	146.46[b]
Number of Tillers (piece/clump)	11.45[a]	12.79[b]	13.32[b]
Plant Height (cm)	89.33[a]	89.67[a]	93.00[a]

Notation: The similar superscript letters in the same row showed insignificant difference (P>0.05)

The table 1 and figure.1, 2, 3 showed that the intercropping of Mott Grass with legumes could increase the number of leaves and tillers of the grass, while the treatment between the Centro and Calopo did not show a significant difference. The highest number of leaves was produced by G_3 treatment (Grass which was intercropped with Calopo) in which the leaves reached to 158.33 strands/clump, while the lowest number of leaves was produced by G_1 treatment with 199.5 strands/clump. The G_2 treatment (Grass which was intercropped with Centro) produced the highest number of tillers by 13.32 pieces/clump, while the G_3 treatment produced 12.79 pieces/clump. However, statistically, both of the treatments did not show a significant difference. Meanwhile, the cultivation of Mott Grass without any legume (G_1) produced 11.45 pieces of tiller/clump that statistically showed significant influence compared to G_2 and G_3 treatments.

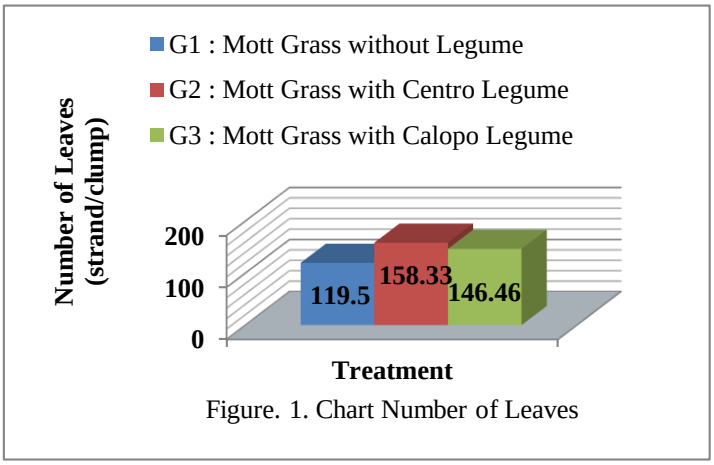

Figure. 1. Chart Number of Leaves

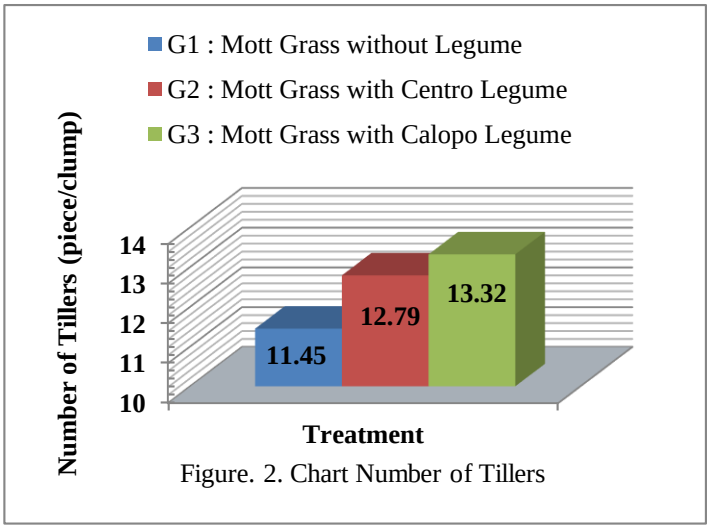

Figure. 2. Chart Number of Tillers

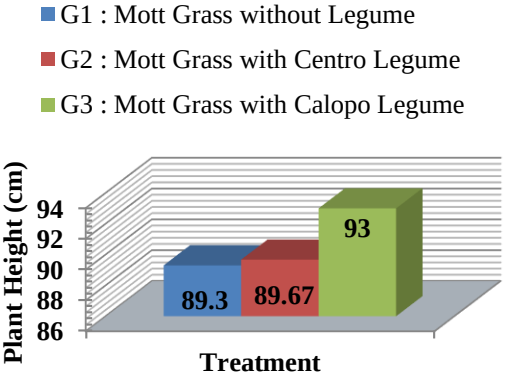

Figure. 3. Chart of Plant Height

The growth of plants was indicated by the length and dry weight of the leaves, which reflected the increase of protoplasm, due to the accretion and enlargement of cells. In this research, the growth of Mott Grass was merely observed in terms of the Number of Leaves, the Number of Tillers, and the Plants' Height. The treatment of Plant' types (Factor A) showed a significant result that could increase the Number of Tillers and Leaves of Mott Grass, though did not show significant influence toward the Plants' High. The average height of Mott Grass for this research was 90.67 cm. The data was suitable with the theory given by (Syarifuddin, 2006), in which the height of Mott Grass could reach 1 meter. The increase of tillers' number would be followed by the increase of leaves' number and the increase of fresh produce. Mott Grass is one of green fodder that grows in clumps with rooting fibers that could produce more tillers if it is pruned regularly. The width of Mott Grass's clumps could reach 1 meter (Anonim, 2005).

3.2 Total Fresh Production and Total Dry Weight Production

The first harvest was carried out after the plants were 12 weeks. The process was done by pruning the grass as long as 10 cm from the soil surface. The Plant's types (Factor A) showed the increase of total fresh production of the green fodder significantly, while the Fertilizer's types (Factor B) showed insignificant influence. The highest number of the Total Fresh Production was reached by G_2 treatment by 99.28 tons/ha. Meanwhile, the lowest number of Total Fresh Production was resulted by G_3 treatment by 97.7 tons/ha. For the G_1 treatment, the Total Fresh Production was 46.35 tons/ha and showed a significant difference ($P<0.01$). The similar cases occurred in the Total Dry Weight Production, in which the G_2 treatment produced the highest number of Total Dry Weight Production by 26.11 tons/ha, followed by G_3 with 25.90 tons/ha, G_1 with 13.04 tons/ha.

Table 2
The Influence of The Type of Plant toward the Total Fresh Production and the Total Dry Weight Production of Mott Grass (*Pennisetum Purpureum* Cv.Mott) (tons/ha)

Parameter	Treatment		
	G_1	G_2	G_3
Total Fresh Production (tons/ha)	46.35^b	99.28^a	97.70^a
Total Dry Weight Production (tons/ha)	13.04^b	26.11^a	25.90^a

Notation: The similar superscript letters in the same row showed insignificant difference ($P>0.05$)

The highest Total Fresh Production was gained by the intercropping of Mott Grass with Centro, followed by the intercropping of Mott Grass with Calopo, and the singular cultivation of Mott Grass. The role of legumes in the association system was to provide nitrogen for Mott Grass and improve the Mott Grass's nutrient content, especially the protein, phosphor, and potassium. Meanwhile, different legumes were aimed to compete based on the root system, the width of leaves, and the other morphological characteristics. The nitrogen need for most of the legumes depended on N from the result of fixation, not the inorganic N. This could influence the growth of legumes very much, in which the inorganic N in the soil could be utilized by other plants [11]. The condition would result in higher production of a pasture mix.

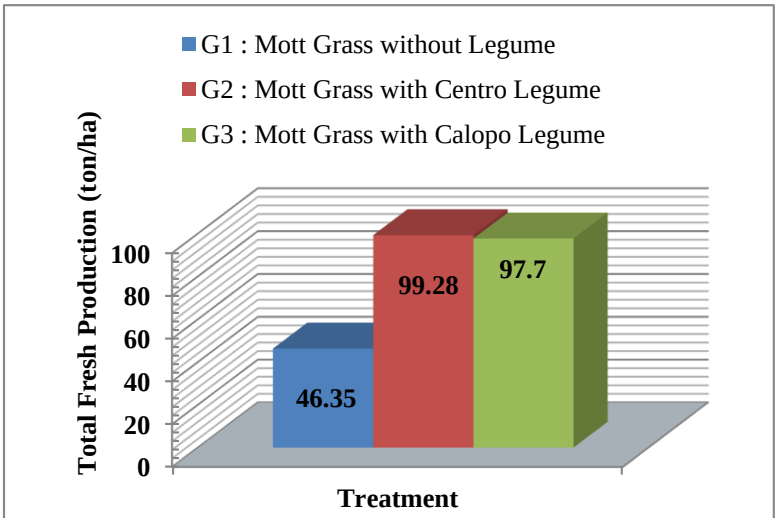

Figure. 4. Chart of Total Fresh Production

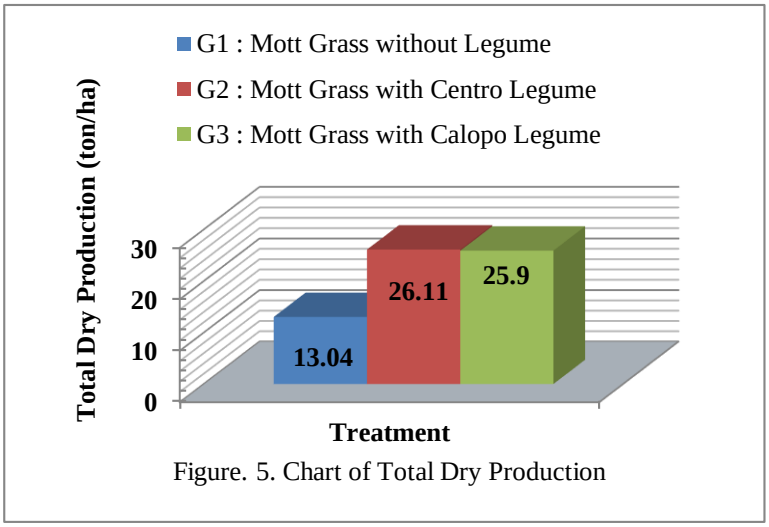

Figure. 5. Chart of Total Dry Production

3.3 Botanical Composition

The intercropping between Mott Grass and legume (Factor A) could decrease the percentage of grass's composition in the botanical composition significantly. Those two variables were also different statistically ($P<0.05$). Meanwhile, the Fertilizer's types (Factor B) resulted in the unsignificant result ($P<0.05$) (table 3 and figure 6, 7, 8). The botanical composition of the G_3 treatment was highly significantly different between the G_2 and G_1 treatments.

The Centro Legume could decrease the growth Mott Grass into the lowest height, in which between Calopo and Centro showed a significant difference (P<0.01). For the botanical composition of legume, the highest percentage was gained by the Centro, and statistically different (P<0.05). Meanwhile, the composition of weeds among the Plant's types showed the significantly different result (P>0.05).

Table 3
The influence of the type of plants toward the botanical composition of mott grass
(*Pennisetum Purpureum* cv. Mott)

Parameter	Treatment		
	G_1	G_2	G_3
Grass Percentage (%)	99.54[a]	64.86[c]	76.28[b]
Legume Percentage (%)	0	34.80[a]	23.27[b]
Weed Percentage (%)	0.46[a]	0.35[a]	0.46[a]

Notation: The similar superscript letters in the same row showed insignificant difference (P>0.05)

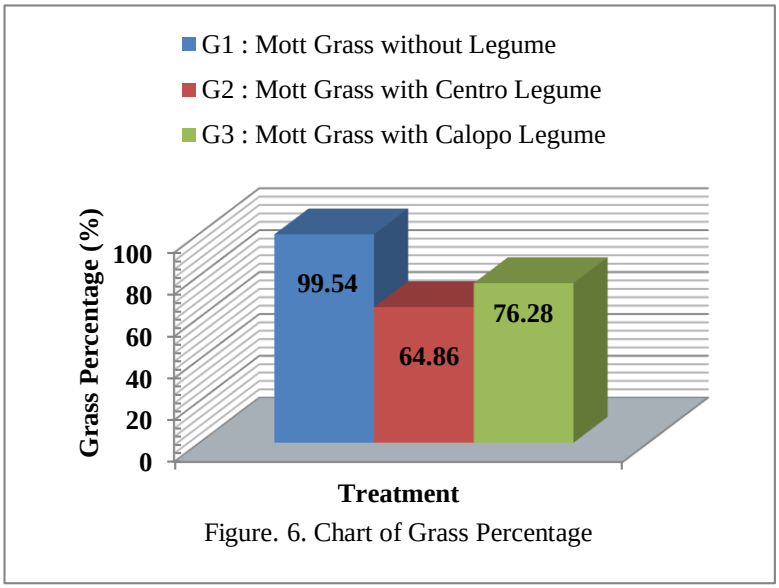

Figure. 6. Chart of Grass Percentage

The treatment of Plant's types (Factor A) gave a significant influence toward the botanical composition. The intercropping between the Mott Grass and legume could significantly decrease the composition of Mott Grass and increase the composition of legume. The weeds composition from the two treatments did not show any influence.

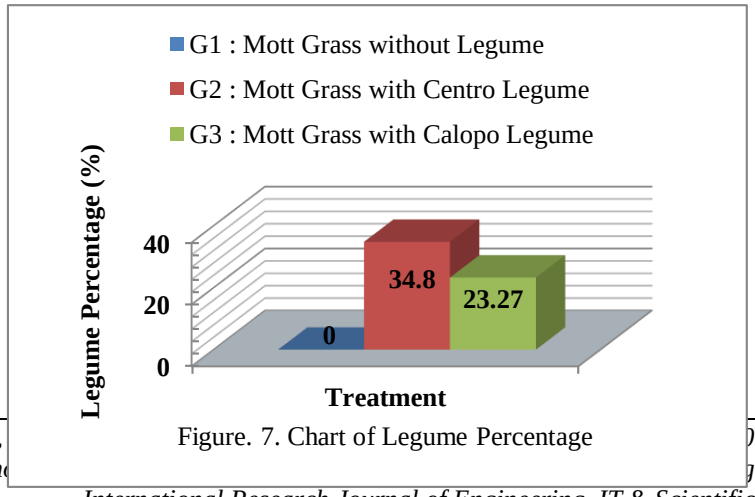

Figure. 7. Chart of Legume Percentage

The association between Mott Grass and legume with a proportion of Mott Grass: Legume = 70%: 30%, is the most expected composition since the ideal composition of fodder is 70% grass and 30% legume. The composition has been reached since the legume's capability to grow back after defoliation was very competitive with grass that has better root system (Whiteman, 1980).

Competition between species of different plants in an association would be different and very depressive, so it would not show a beneficial interaction. The competition would occur if two or more plants needed light, nutrient, and water beyond the availability. The competition, after all, would decrease the number of essential factors for each plant. The plant which was more competitive in the association would normally grow and spread faster, as well as produce more forage.

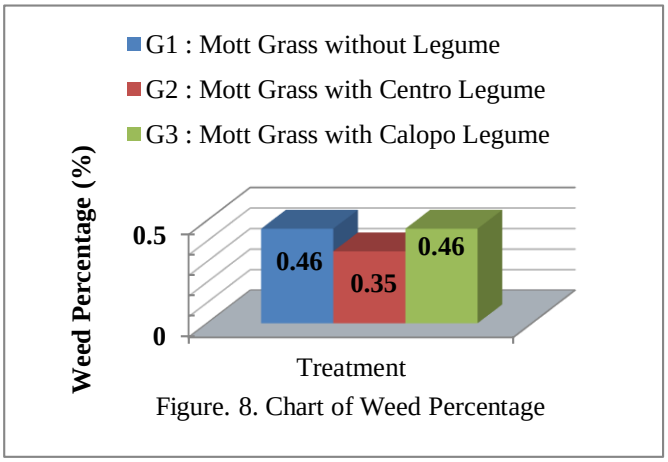

Figure. 8. Chart of Weed Percentage

3.4 Nutritional Quality

The nutritional quality which was observed namely the crude protein content, whether the protein content of the intercropped plants or the merely grass cultivation. Based on the result of the research, it was known that the Plat's types (Factor A) showed a significant influence of the crude protein content of Mott Grass. Meanwhile, the Fertilizer's types (Factor B) did not show a significant influence ($P<0.05$) and there was not any relation between the type of fertilizer and the crude protein content. The crude protein contents of Mott Grass which was planted with legumes (G_2 and G_3), were discovered to be higher than the singular cultivation (G_1), in which the crude protein content of G_2 was 10.40% and the crude protein content of G_3 was 12.87%. Statistically, the crude protein content of the intercropped and singular cultivations was significantly different ($P<0.05$). The G_3 treatment resulted in higher crude protein content (2.24%) compared to G_3's, though statistically, the crude protein contents were not significantly different ($P<0.05$) (Table 4, and Figure. 9, 10).

Table 4
The influence of the type of plant toward the quality of nutrition of mott grass
(*Pennisetum Purpureum* cv. Mott)

Parameter	Treatment		
	G_1	G_2	G_3
Crude Protein (%)	8.08^b	8.92^a	9.12^a
Crude Fiber (%)	32.02^a	32.33^a	32.70^a

Notation: The similar superscript letters in the same row showed insignificant difference ($P>0.05$)

There are some factors that influence the composition of forage, namely (1) soil effect, the fertility of soil physically, chemically, and biologically is needed; (2) plant effect, namely the type of plant, the age of plant, and the part of

plant, (3)weather effect, namely the temperature, the rainfall, and the humidity (Djuned *et al.*, 1980). The nutritional quality of Mott Grass increased along with the intercropping of Mott Grass and legumes. The Plant's types (Factor A) increased the crude protein content of Mott Grass significantly. Meanwhile, the singular cultivation of Mott Grass (G_1) resulted in the lowest crude protein content by 8.08%. The intercropping of Mott Grass whether with Centro or Calopo could increase the crude protein content of Mott Grass by 8.92% for G_2 and 9.12% for G_3. In intercropped cultivation between grass and legume, the legume would supply N to the grass in form of root nodules, in which the nodules would be utilized by the grass to grow and improve its production (McIlroy, 1977). A different theory was stated by Bogdan (1977), in which during the growth of intercropped plant, N that produced by the legume would mainly utilize by the legume itself and transferred to the grass in a very limited quantity. The N transfer in legume did not have any correlation with the number of N that fixed by the legume. In rhizobium-legun symbiosis, the legume provides carbohydrate that would be utilized by the rhizobium as the source of energy, whereas the rhizobium would provide N that could be utilized by the legume to synthesize amino acids and protein (Skerman, 1977).

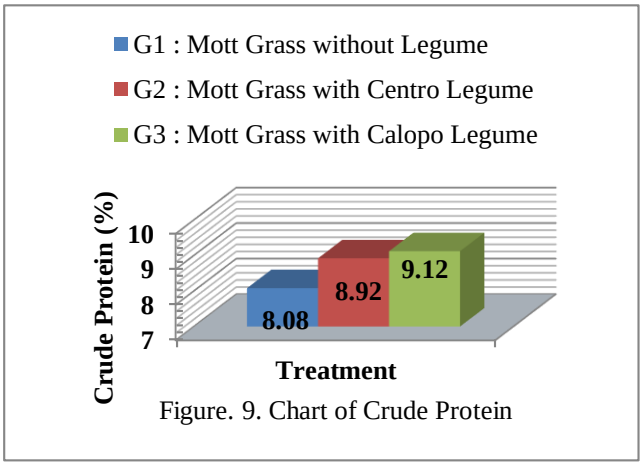

Figure. 9. Chart of Crude Protein

McIlroy (1977) stated, the intercropping between grass and legume could be an alternative to utilize a land efficiently. The intercropping would be beneficial since the legume could provide N for the grass, so the production of grass could be improved, besides suppressing the use of fertilizer. The nutritional quality of forage was also stated to be influenced by the ratio of leaves/stems, growth phase, soil fertility, fertilization, and weather. Generally, the legume is rich of N, P, and K compared to grass.

The nodulation of legume could also maintain the high protein concentration of the grass, so the existence of legume could result the better quality of forage (Skerman, 1977). Though grass could result in high production, however, the protein content is tended to be lower compared to the legume. According to Sanchez (1993) the role of legume in the grass-legume intercropping would provide additional N for the grass, and at the same time improving the soil nutrients, particularly the protein, phosphor, and potassium. The grass was expected could provide the amount of energy for livestock, since the production of its dry material was considered to be higher. Besides, the intercropping system could result qualified forage, since the good composition of forage is composed of grass and legume (Dubbs, 1971). The grass-legume intercropping would also produce unfluctuating forage in each season (Miller, 1984). McIlroy (1977) stated, legume could bind nitrogen from the atmosphere in symbiosis with Rhizobium bacteria.

Grass and legume are sources of forage with the different cycle of photosynthesis. Most of the tropical grasses have a C4 cycle, while legumes have C3 cycle. The CO_2 fixation of plants with C3 and C4 cycles could be influenced directly. The leaves of plants with C3 fixation would be saturated fast at low light intensity, compared to those with C4 fixation. Therefore, plants with C3 fixation would be more suitable for a shaded habitat. On the other hand, plants with C4 would be more efficient in using water, therefore those would be more competitive compared to other plants (Sastrautomo, 1990). In term of the fixation pattern, the grass and legume are very suitable for intercropping.

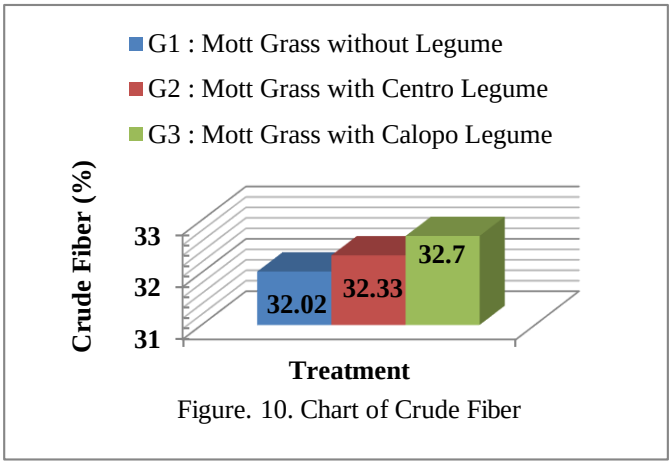

Figure. 10. Chart of Crude Fiber

Grass-legume crop association in the pasture mix does not need nitrogen addition if the legume composition beyond the 30% from the intercropping. Nevertheless, the phosphor and potassium fertilizations are still needed (Miller, 1984). The need of nitrogen would be fulfilled by the legume to support the growth of the grass, as the component of a pasture mix. After the decline of legume component below 30%, fertilization is needed to increase the production of grass. Further, Djuned *et al.*, (1980) stated, there were some factors that influence the chemical composition of forage, such as the plant factor, namely the age of the plant, the type of the plant, and the part of the plant. Leaves contain higher protein content compared to the stems of the stems contain more fiber content.

4. Conclusion

Based on the result and discussion of the study, it could be concluded that:

a) There was not any interaction between the Plant's type and the Fertilizer's type toward the Growth, Production, Botanical Composition, and the Nutritional Quality of the Mott Grass.
b) The Plant's type affected the growth parameters significantly, especially the Number of Tillers and Leaves, the Total Production of Fresh and Dry Forage, Botanical Composition (the percentage of Mott Grass and Legumes), and the Nutritional Quality (the crude protein content) of the Mott Grass; but did not affect the Plants' Height, the crude fiber content, and the percentage of weeds significantly.
c) The type of fertilizer did not affect the growth, the production, the botanical composition, and the quality of nutrient content of the Mott Grass.

Suggestion

Further, more research about the intercropping of Mott Grass with others legumes or utilizing different fertilizer is needed.

Conflict of interest statement and funding sources

The author(s) declared that (s)he/they have no competing interest. The study was financed by the authors.

Statement of authorship

The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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