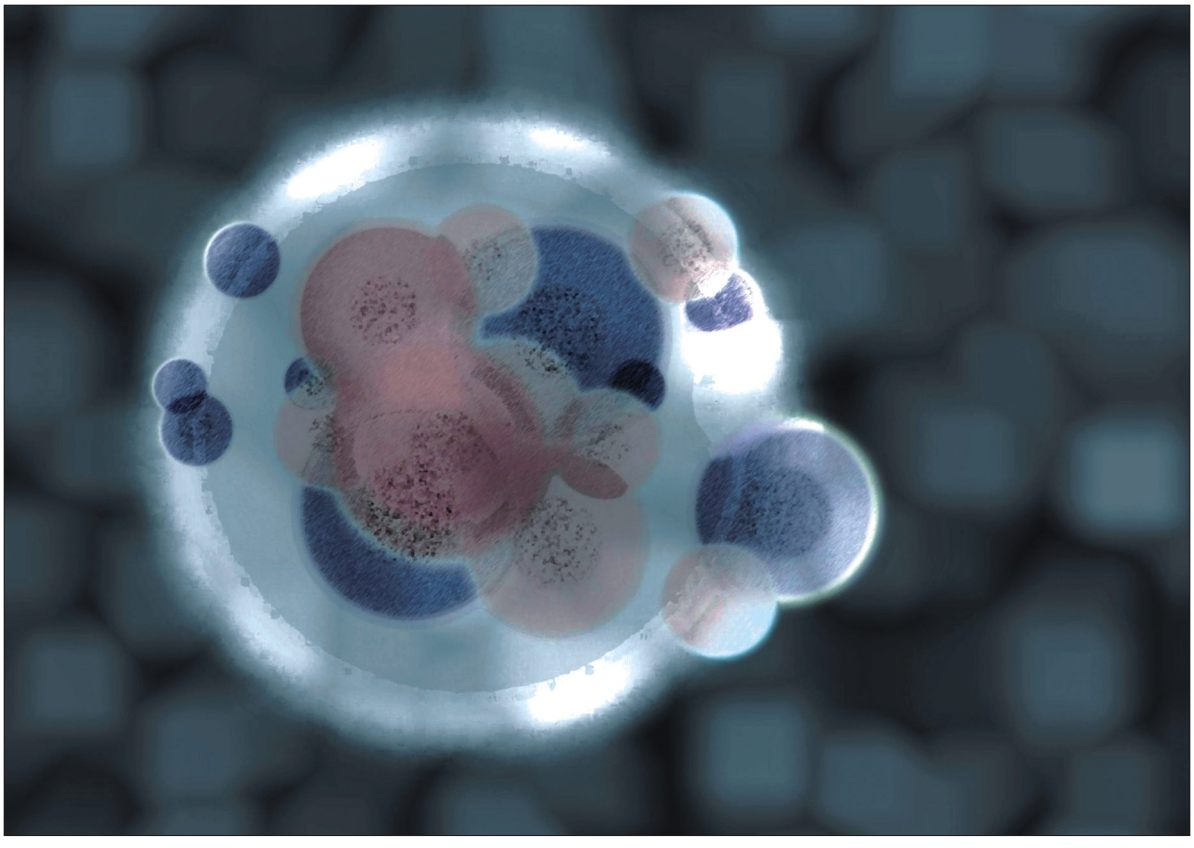

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Journal of Biological Sciences

ISSN 1727-3048
DOI: 10.3923/jbs.2020.116.122

Research Article
Effect of Grass Variety and Shade under Palm Oil Plantation on Production and Proportion of Stems, Leaves and Nutrition Content of Grass

Muhtarudin, Winda Puspita Sari, Desi Savitri, Farida Fathul, Erwanto, Liman, Agung Kusuma Wijaya, Akhmad Dakhlan and Kusuma Adhianto

Department of Animal Husbandry, Faculty of Agriculture, University of Lampung, Jl. Prof. Sumantri Brojonegoro No. 1 Bandar Lampung 35145, Lampung, Indonesia

Abstract

Background and Objective: There are several varieties of grass that have resistance to shade and the quality is not disturbed by the shade. Grass that is resistant to shade will have high production and quality even though it grows in shaded areas. This research investigated the effect of grass variety and shade under palm oil plantation on fresh and dry matter production, stems and leaves proportion and nutrition content of grass. **Materials and Methods:** Split plot with completely randomized design was used in this study. Main plot factor was land condition of land without shade (N_0) and land shaded under palm oil plantation (N_1) and subplot factor was variety of grass consisted of *Pennisetum purpureum* (A_1), *Setaria sphacelata* (A_2) and *Pennisetum purpureum* cv. Mott (A_3). Duncan multiple range test was performed to investigate the effect of the factors. **Results:** Results showed that there was interaction ($p<0.01$) between grass variety and land condition on proportion of stems and leaves of grass with the highest fresh and dry matter production was *Pennisetum purpureum* on land without shade. Under shade of oil palm plantation, *Pennisetum purpureum* produced the highest proportion of stems, while *Pennisetum purpureum* cv. Mott produced the highest proportion of leaves. Shading treatment not significant ($p>0.05$) on crude protein content, but it affected ($p<0.05$) on crude fiber content. Furthermore, different variety of grass had no effect ($p>0.05$) on crude protein content, although this factor affected ($p<0.05$) on crude fiber content. *Pennisetum purpureum* cv. Mott in palm oil shade produced high crude protein (13.79%) with low crude fiber (24.63%). **Conclusion:** These results suggested that *Pennisetum purpureum* cv. Mott could be planted in shaded land.

Key words: Productivity, shade, *Pennisetum purpureum*, *Setaria sphacelata*, *Pennisetum purpureum* cv. Mott, plantation, shaded land, nutritional content

Citation: Muhtarudin, Winda Puspita Sari, Desi Savitri, Farida Fathul, Erwanto, Liman, Agung Kusuma Wijaya, Akhmad Dakhlan and Kusuma Adhianto, 2020. Effect of grass variety and shade under palm oil plantation on production and proportion of stems, leaves and nutrition content of grass. J. Biol. Sci., 20: 116-122.

Corresponding Author: Kusuma Adhianto, Department of Animal Husbandry, Faculty of Agriculture, University of Lampung, Jl. Prof. Sumantri Brojonegoro No. 1 Bandar Lampung 35145, Lampung, Indonesia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The availability of feedstuff, especially forage, both in quality and quantity and also, its continuity is an important factor in determining the success of ruminant livestock farming. This is because almost 90% of ruminant feedstuff is originated from forage with fresh consumption per day of 10-15% of body weight, while the rest is originated from concentrate and supplementary feed (feed supplement)[1].

As the human population increases, the availability of land that can be used for the development of extensive fodder is diminishing. Provision of land for livestock is indeed limited. Meanwhile, the need for livestock (especially ruminants) for the availability of forages is also increasing to meet human needs for food (animal protein). Given that the current condition of many land used as residential and industrial areas which causes the reduction of open land, it is necessary to do further solutions in efforts to provide land. The effort is carried out by utilizing the oil palm plantation area to plant several varieties of grass. Indonesia is the world's largest palm producing country with an area of almost 12.30 million ha of oil palm in 2017, a value that is about three times higher than in the year 2000 when around 4 million ha of Indonesian soil was used for palm oil plantations. This value is expected to increase to 13 million ha by the year 2020[2].

The vast land area of production and plantation forests makes it possible to use the land for the development of grass cultivation as forage for livestock. However, in reality, this integrated development faces obstacles. The constraints in the integration system are the low light intensity which affects forage production. Most tropical grasses, except shade-resistant ones, even though their nutrient and water needs are met, production will be low if it grows in shaded places, compared to those that get full sunlight or irradiation, grass tolerance to shade depends on the ability of the grass to adapt, morphologically and physiologically, to a particular level of irradiance. Under conditions of moderate shade, grasses can continue to grow at levels considered to be satisfactory[3-5].

There are several varieties of grass that have resistance to shade and the quality is not disturbed by the shade. Grass that is resistant to shade will have high production and quality even though it grows in shaded areas[4-8]. This present research tried to investigate the effect of oil palm plantation shade on grass productivity. It is also necessary to identify the varieties of grass that has good quality nutrition planted under oil palm shade.

MATERIALS AND METHODS

Study area: This research was carried out in January-May, 2018 in shaded area under oil palm plantation which aged 7 years with planting distance of 5-7 m and in open land (no shade) around oil palm plantations located in the Tanjung Agung village, Katibung district, South Lampung regency, Lampung, Indonesia. Proximate analysis was carried out at the Animal Nutrition and Feed Laboratory, Faculty of Agriculture, Lampung University, Indonesia.

Research procedure: This research was carried out using a split plot with a completely randomized design. The main plot treatment was land without shade (N_0) and land shaded under oil palm plantation (N_1), while the subplot treatments in each of the main treatments were variety of grass consisted of three varieties, *Pennisetum purpureum* (A_1), *Setaria sphacelata* (A_2) and *Pennisetum purpureum* cv. Mott (A_3). Each experimental unit is a plot with size of 2.40×2.25 m^2. Each experimental unit was repeated four times, so there were 24 experimental units in this study.

The variables observed in this study were fresh and dry matter production of grass, proportion of stems and leaves of grass and crude protein and crude fiber content of grass. The obtained data were analyzed for variance significant by using "agricolae" packages[9] and continued by further test using the Duncan Multiple Range Test (DMRT) using the package.

RESULTS AND DISCUSSION

Fresh production of grass: Results of the analysis of variance (Table 1) showed that there was an interaction between shade treatment and grass variety ($p<0.05$) on the fresh production of grass with *Pennisetum purpureum* (A_1N_0) was the highest fresh production (159.52 t/ha/harvest). This may be caused by

Table 1: Fresh production of three different grass varieties on two different land condition (t/ha/harvest)

	Shade treatments		
Grass variety	N_0	N_1	Average
A1	159.52^a	3.24^c	81.38
A2	81.99^b	4.63^c	43.31
A3	94.52^b	6.65^c	50.59
Average	112.01	4.84	13.41*

N_0: Land without shade, N_1: Land shaded under palm oil plantation, A_1: *Pennisetum purpureum*, A_2: *Setaria sphacelata*, A_3: *Pennisetum purpureum* cv. Mott., ^{a,b,c}Different superscripts within rows and columns indicate differences at $p<0.05$, *Pooled SEM

differences in the intensity of light in the shaded land and without shade used for the photosynthesis process, so it can be seen that the shaded area by oil palm plantation was not responded well by the grass being tried. This result indicated that *Pennisetum purpureum* is better if planted on land without shade meaning that *Pennisetum purpureum* is one of the grasses that requires good light intensity.

Shade is not responded well by the grass because the number of tillers on the shaded land is very small due to decay on the main stem. The decay is caused by lack of absorption of sunlight. According to De Alvarenga *et al.*[10] that, plants which are planted in the condition without shade tend to have higher root weight production when compared to shaded plants. However, an increase in leaf area was reported with increasing shade levels.

The highest production of grass in shaded land was *Pennisetum purpureum* cv. Mott. in this study which was 6.65 t/ha/harvest. *Pennisetum purpureum* cv. Mott. in this study maybe more resistant to shade, hot weather or drought. In addition, the number of tillers of *Pennisetum purpureum* cv. Mott. was greater than those of *Pennisetum purpureum*. This result suggested that *Pennisetum purpureum* cv. Mott. could be planted in shaded area resulted in more fresh production of grass compared to other varieties of grass in this study although statistically not different.

Dry matter production: Results of this study showed that there was interaction ($p<0.06$) between shade treatment and variety of grass on dry matter production of grass. The highest dry matter production was *Pennisetum purpureum* planted on land without shade (A_1N_0) (23.49 t/ha/harvest). The average dry matter production of grass on open land was 16.72 t/ha/harvest, while the average dry matter production of grass due to shaded land was 0.70 t/ha/harvest (Table 2).

The significant interactions between shade and grass variety on dry matter production of grass maybe caused by plants having different characteristics. The amount of grass production is also influenced by the efficiency of the use of light that has been absorbed. This is consistent with the results of Van Huylenbroeck and Van Bockstaele[11]that each variety of grass has a different response to the provision of shade.

The character of each grass variety or species has a different response to shade. This different response is in accordance with the statement of Samarakoon *et al.*[12] who explained that species that are resistant to shade often show a relatively small decline in production or still increase in moderate shade. Sirait[13] added that *Pennisetum purpureum* cv. Mott. is a superior variety of grass because of its high productivity and nutrient content. These grasses can live in various places are tolerant to shade, respond to fertilization and require a high level of soil fertility.

Table 2: Dry matter production of three different grass varieties on two different land condition (t/ha/harvest)

	Shade treatments		
Grass variety	N_0	N_1	Average
A1	23.49[a]	0.48[c]	11.98
A2	12.55[b]	0.68[c]	6.61
A3	14.11[b]	0.94[c]	7.52
Average	16.72	0.70	2.01*

N_0: Land without shade, N_1: Land shaded under palm oil plantation, A_1: *Pennisetum purpureum*, A_2: *Setaria sphacelata*, A_3: *Pennisetum purpureum* cv. Mott., [a,b,c]Different superscripts within rows and columns indicate differences at $p<0.06$, *Pooled SEM

The average dry matter production of grass on land without shade and land shaded under oil palm plantation were 16.72 and 0.70 t/ha/harvest, respectively. This result indicated that shade can reduce the amount of dry matter production of grass. Salisbury and Ross[14] explained that light intensity is one of the most important factors in plant growth. Relatively slow growth in all grass species is due to lack of light. However, many grass species can grow well at light intensities that are less than full light. Directly, light intensity affects growth through chlorophyll synthesis, photosynthetic light reaction phase, hormone synthesis and stomata opening. Cruz[15] argued that shade can reduce photosynthetic enzymes that function as catalysts in CO_2 fixation and reduce light compensation points. Wilson and Ludlow[16] explained that shade could decreases leaf and stem ratios, but increases the level of forage lignin. The same thing was reported by Sanchez[17] who stated that various mixed pastures, grasses have different responses in producing dry matter. Wong and Wilson[18] added that most tropical plants, especially grass, decreased production is in line with the decreasing light intensity, but shade-resistant species were relatively small or still increasing in moderate shade.

Pennisetum purpureum has the highest dry matter production on land without shade ($p<0.05$). This is caused by the intensity of light on land without shade higher, so that the production of dry matter is also high. Adaptability and absorption of light for *Pennisetum purpureum* were better so that dry matter production of *Pennisetum purpureum* was quite high compared to *Setaria sphacelata* and *Pennisetum purpureum* cv. Mott. Vanis[19] explained that the adaptation of *Pennisetum purpureum* is very wide ranging from light, medium to heavy texture soil and even in infertile soils that are poorly managed, *Pennisetum purpureum* still produce high forage. The soil conditions needed to produce optimal production for *Pennisetum purpureum* are moist soil (60-70%).

Table 3: Proportion of stems of three different grass varieties in two different land condition

	Shade treatments		
Grass variety	N_0	N_1	Average
A1	71.20[a]	47.04[b]	59.12
A2	38.67[c]	38.41[c]	38.54
A3	36.86[c]	27.13[d]	31.99
Average	48.91	37.53	2.93*

N_0: Land without shade, N_1: Land shaded under palm oil plantation, A_1: *Pennisetum purpureum*, A_2: *Setaria sphacelata*, A_3: *Pennisetum purpureum* cv. Mott., [a,b,c,d]Different superscripts within rows and columns indicate differences at p<0.05, *Pooled SEM

Table 4: Proportion of leaves of three different grass varieties in two different land condition

	Shade treatments		
Grass variety	N_0	N_1	Average
A1	28.80[d]	52.96[c]	40.88
A2	61.34[b]	61.59[b]	61.46
A3	63.14[b]	72.87[a]	68.01
Average	51.09	62.47	2.93*

N_0: Land without shade, N_1: Land shaded under palm oil plantation, A_1: *Pennisetum purpureum*, A_2: *Setaria sphacelata*, A_3: *Pennisetum purpureum* cv. Mott., [a,b,c,d]Different superscripts within row sand columns indicate differences at p<0.05, *Pooled SEM

The dry matter production of *Pennisetum purpureum* cv. Mott. (A_3) was higher compared to *Pennisetum purpureum* (A_1) and *Setaria sphacelata* (A_2) in shade land although statistically not different (p>0.05). This is due to the more resistance of the *Pennisetum purpureum* cv. Mott. to shade compared to other grasses. Sirait[13] stated that the advantage of *Pennisetum purpureum* cv. Mott. is that the stem is relatively short and tender, growth is relatively faster, leaves are soft and hairless, able to adapt to land conditions and does not require special care. The production of this *Pennisetum purpureum* cv. Mott. varied and was influenced by various factors, including agro-climate, spacing and cultivation management.

Proportion of forage stems and leaves

Proportion of stems: Results of variance analysis showed that there was an interaction between shade and grass variety (p<0.01) on the proportion of stems (Table 3). The result showed that the highest proportion of stems was *Pennisetum purpureum* in non-shaded area (A_1N_0), while the smallest was *Pennisetum purpureum* cv. Mott. in shaded land (A_3N_1). This indicated that the proportion of stems was determined by each grass variety/species and the condition of the experimental land. The production of stems on shaded land is smaller compared to land without shading.

The proportion of forage stems of *Pennisetum purpureum*, *Setaria sphacelata* and *Pennisetum purpureum* cv. Mott. on land without shade was greater than that of shaded land. This is presumably because the grass in the shade area grows imperfect or experiences stunting so that the production is low which can affect the proportion of stems and leaves of the grass. Manggiring *et al.*[20] explained that forages growing in shaded land would reduce the forage nutrients. This decrease is caused by sunlight not entirely reaching the forage because it is blocked by shade. Therefore, the results of photosynthesis are not optimal and ultimately interfere with forage growth. In addition, the presence of shade can prevent sunlight from entering the grass area, so that the photosynthesis process is inhibited.

The highest proportion of stems in this study was *Pennisetum purpureum*. This is because *Pennisetum purpureum* has large and hard stems compared to *Setarias phacelata* and *Pennisetum purpureum* cv. Mott. The stem formed is influenced by the fertilization of N, P, K which plays a role in the formation of stems and leaves which was optimal in *Pennisetum purpureum*, so that the proportion of stems is much higher than leaves. Buckman and Brady[21] explained that the amount of nutrient uptake by plants will increase photosynthesis process, so that more carbohydrates will be produced by plants which will help the formation of stems and leaves.

Proportion of leaves: The results showed that there was an interaction between shade and variety of grass (p<0.01) on the proportion of forage leaves (Table 4). Significant interactions between shade and grass variety on the proportion of grass leaves indicated that the proportion of leaves was determined by each grass variety and land conditions. The production of leaves in shaded land was smaller compared to land without shade.

The proportion of forage stems of *Pennisetum purpureum*, *Setaria sphacelata* and *Pennisetum purpureum* cv. Mott. on land without shade was greater than that of those on shaded land. This is due to the inhibition of photosynthesis for grasses in land shaded under oil palm plantation. Forage that have been forcibly cut will re-grow. The initial period of re-growth will use part of the nutrients for the growth of young leaves and stems. Leaves are the place where photosynthesis and respiration occur, so young forages will have a higher percentage of leaf proportions. Leaf growth will be followed by cleavage of forage stem cells. Gardner[22] explained that light energy is responsible for photosynthetic activity and a number of N binding through chemical reactions. The function and structure of leaves is one of the plant organs that grows from the stem, generally green (containing chlorophyll) and mainly functions as a catcher of

energy from sunlight for photosynthesis. Furthermore, leaves are the most important organ for plants to live because they are obligate autotrophic organisms, so they must supply its own energy needs, through the conversion of light energy into chemical energy. Disruption of the process of catching sunlight will affect the growth and production of plants.

The highest leaf proportion was found in *Pennisetum purpureum* cv. Mott. in the shade area ($p<0.05$). This is caused by genotype and environmental factors such as; nutrients and organic matter. The proportion of leaves in *Pennisetum purpureum* cv. Mott. is also caused by a large number of tillers. Fitter and Hay[23] explained that the formation of stems and leaves and the number of more tillers will support photosynthesis. The optimal photosynthesis rate is supported by bright sunlight during plant growth which causes photosynthesis to be maximized. *Pennisetum purpureum* cv. Mott. is a grass that is quite resistant to shade so, that the production of leaves is still quite high in shade land. Rellam *et al.*[24] added that the interaction effect between the levels of nitrogen fertilizer with 70% shade resulted in the length of leaves, number of leaves and the best height of plants.

Crude protein content: The results showed that there was no interaction between shade and grass variety ($p>0.05$) on crude protein content of grass. Shade treatment affected ($p<0.07$) on crude protein content of grass, while different variety of grass has no effect ($p>0.05$) on crude protein content of grass. The results of this study (Table 5) showed that planting grass in shaded land increased crude protein content. Grasses planted under oil palm shade had an average crude protein content of 13.42% and grass planted on land without shade obtained an average crude protein content of 11.99%. This result is in accordance with the result of Norton *et al.*[25] who stated that plants grown under shade had a higher nitrogen content compared to plants grown on open land.

The difference in protein levels obtained is due to the ability of grass to more easily absorb the availability of soil nitrogen under shaded conditions[16,26], so that even though the nitrogen content in unshaded land is higher than that in coconut shade palm, the crude protein content of grass grown under oil palm shade is higher. The land used in this study has moderate quality based on the availability of nitrogen in the soil. The condition of the soil under oil palm shade has a nitrogen content of 0.212%, C-organic 0.979% and C/N ratio 4.61. Soil conditions on unshaded land have a nitrogen content of 0.444%, C-organic 1.72% and C/N ratio of 3.88. Hardjowigeno[27] said that the criteria for assessing the chemical properties of soils under moderate or normal conditions have a nitrogen content of 0.21-0.50% and carbon content of 2.01-3.00% with a C/N ratio of 8-12.

Table 5: Crude protein content of three different grass varieties in two different land condition

	Shade treatments		
Grass variety	N_0	N_1	Average
A1	11.09	12.60	11.85
A2	11.67	13.88	12.77
A3	13.24	13.79	13.52
Average	11.99^b	13.42^a	0.38*

N_0: Land without shade, N_1: Land shaded under palm oil plantation, A_1: *Pennisetum purpureum*, A_2: *Setaria sphacelata*, A_3: *Pennisetum purpureum* cv. Mott., ^{a,b}Different superscripts within rows indicate differences at $p<0.07$, *Pooled SEM

Table 6: Crude fibre content of three different grass varieties in two different land condition

	Shade treatments		
Grass variety	N_0	N_1	Average
A1	33.06	30.05	31.56^a
A2	27.96	25.40	26.68^b
A3	30.32	24.63	27.48^b
Average	30.45^a	26.70^b	0.81*

N_0: Land without shade, N_1: Land shaded under palm oil plantation, A_1: *Pennisetum purpureum*, A_2: *Setaria sphacelata*, A_3: *Pennisetum purpureum* cv. Mott., ^{a,b}Different superscripts within rows or within columns indicate differences at $p<0.05$, *Pooled SEM

The crude protein content of *Pennisetum purpureum*, *Setaria sphacelata* and *Pennisetum purpureum* cv. Mott. planted in oil palm shade is higher than that planted in unshaded land. This is because the shaded conditions of the three varieties of grass have a higher proportion of leaves than the proportion of stems. The higher the proportion of leaves in plants indicated the higher the crude protein content it has because most of the protein is contained in the leaves. This is consistent with the statement of Suryana and Lugiyo[28] that plant protein is closely related to tissue activity, so the leaves contain more protein than the stem.

Crude fibre content: The results showed that there was no interaction between shade treatment and grass variety ($p>0.05$) on crude fiber content of grass. The results of the variance analysis also showed that land condition and grass variety affected ($p<0.05$) on the crude fiber content of grass. This showed that shade can reduce the crude fiber content of grass. The existence of shade can inhibit the occurrence of lignification processes in parts of the plant due to lack of light intensity.

Grass planted under oil palm shade with crude fiber content of 26.70% was lower ($p<0.05$) than those planted in land without shade (30.45%) as shown in Table 6. This

difference in crude fiber can be caused by differences in the rate of grass growth in both fields due to the different photosynthetic rates.

Grasses planted in oil palm shade have slower growth rates than grass planted in unshaded land. This is because photosynthesis of grass in shaded land run less due to the light that reaches the land under the shade of oil palm in small amounts compared to those in unshaded land. This is consistent with the statement of Salisbury and Rose[29] that shade caused the light compensation point to be very low and causes stunted grass growth.

The intensity of light that reaches the grass influences the process of grass growth itself, because it can affect photosynthesis in grass. Measuring the intensity of light that has been done indicated that the value of light intensity on land under oil palm shade was 2,006.7 lux and on the land without shade was 12,093.3 lux. This is consistent with the statement of Bona and Monteiro[30] that the limitations of light due to shade can affect photosynthesis.

The results of this study also showed that the content of crude fiber of *Pennisetum purpureum* was higher than that of *Setaria sphacelata* and *Pennisetum purpureum* cv. Mott. ($p<0.05$), whereas the crude fiber content of *Pennisetum purpureum* cv. Mott. and *Setaria sphacelata* were not different ($p>0.05$). The difference in crude fiber content is caused by differences in the ratio of stems and leaves in all three variety of grass. *Pennisetum purpureum* has a higher stem ratio than other varieties of grass on land under oil palm shade and on non-shaded land. Crude fiber content of grass in this study is lower than that of the result of Fathul *et al.*[31], who reported that the content of crude fiber in *Pennisetum purpureum* was 32.60% and in *Setaria sphacelata* was 33.70%.

Grass planted on unshaded land tends to have higher crude fiber content than grass planted under oil palm shade. This is because grass planted in land conditions without shade tended to have higher levels of dry matter so that the level of crude fiber produced is higher. This is in accordance with the statement of De Alvarenga *et al.*[10] that plants grown in land without shade tend to have a higher production of stem weight than those in shaded land. Based on the result of this research *Pennisetum purpureum* cv. Mott. could be more recommended to be planted in shaded land compared to other varieties in this study.

CONCLUSION

Based on the results of the research it can be concluded as follows:

- There was an interaction between land condition and grass variety on fresh and dry matter production of grass and on the proportion of stems and leaves of grass
- There was no interaction between land condition and grass variety on crude protein and crude fiber content of grass
- The variety of grass that has the highest fresh and dry production on shade under oil palm is *Pennisetum purpureum* cv. Mott.
- In shaded land crude protein content of grass is higher with crude fibre content lower compared to those in open land

SIGNIFICANCE STATEMENT

This research results in the possibility to increasing forage production by integrating with palm oil plantations, an effort to meet the needs of ruminant animal feed. This study also provides an overview of efforts to utilize forage sources that can be used as animal feed.

ACKNOWLEDGMENTS

The research was supported by the Agricultural Research grants with number SPK.2214.B/UN26.14/PN.01.00/2018 by the Faculty of Agriculture, University of Lampung, Indonesia.

REFERENCES

1. Central Bureau of Statistics of Indonesia, 2018. Statistik Kelapa Sawit Indonesia 2018. Badan Pusat Statistik BPS-Statistics, Indonesia.
2. Dias-Filho, M.B., 2000. Growth and biomass allocation of the C4 grasses *Brachiaria brizantha* and *B. humidicola* under shade. Pesq. Agropec. Bras., 35: 2335-2341.
3. Paciullo, D.S.C., C.A.B. Carvalho, L.J.M. Aroeira, M.J.F. Morenz, F.C.F. Lopes and R.O.P. Rossiello, 2007. Morphophysiology and nutritive value of signalgrass under natural shading and full sunlight. Pesq. Agropec. Bras., 42: 573-579.
4. Guenni, O., S. Seiter and R. Figueroa, 2008. Growth responses of three *Brachiaria* species to light intensity and nitrogen supply. Trop. Grasslands, 42: 75-87.
5. Soares, A.B., L.R. Sartor, P.F. Adami, A.C. Varella, L. Fonseca and J.C. Mezzalira, 2009. Influence of luminosity on the behavior of eleven perennial summer forage species. Rev. Bras. Zootec., 38: 443-451.
6. Paciullo, D.S.C., N.R. Campos, C.A.M. Gomide, C.R.T. de Castro, R.C. Tavela and R.O.P. Rossiello, 2008. Growth of signalgrass influenced by shading levels and season of the year. Pesq. Agropec. Bras., 43: 317-323.

7. Rozados-Lorenzo, M.J., M.P. Gonzalez-Hernandez and F.J. Silva-Pando, 2007. Pasture roduction under different tree species and densities in an *Atlantic silvopastoral* system. Agrofor. Syst., 70: 53-62.
8. Sousa, L.F., R.M. Maurício, L.C. Gonçalves, E.O.S. Saliba and G.R. Moreira, 2007. Productivity and nutritional value of *Brachiaria brizantha* cv. Marandu in a silvopastoral system. Arq. Bras. Med. Vet. Zootec., 59: 1029-1037.
9. De Menndiburu, F., 2017. Statistical procedures for agricultural research. https://cran.r-project.org/web/packages/agricolae/agricolae.pdf.
10. De Alvarenga, A.A., E.M. de Castro, E.D.C. Lima Junior and M.M. Magalhaes, 2003. Effects of different light levels on the initial growth and photosynthesis of *Croton urucurana* Baill. in Southeastern Brazil. Rev. Árvorev., 27: 53-57.
11. Van Huylenbroeck, J.M. and E. van Bockstaele, 2001. Effects of shading on photosynthetic capacity and growth of Turfgrass species. Int. Turfgrass Soc. Res. J., 9: 353-359.
12. Samarakoon, S.P., J.R. Wilson and H.M. Shelton, 1990. Growth, morphology and nutritive quality of shaded *Stenotaphrum secundatum*, *Axonopus compressus* and *Pennisetum clandestinum*. J. Agric. Sci., 114: 161-169.
13. Sirait, J., 2005. Pertumbuhan dan serapan nitrogen rumput pada naungan yang berbeda. M.Sc. Thesis, Pascasarjana Institut Pertanian Bogor, Bogor, (In Indonesian).
14. Salisbury, F.B. and C.W. Ross, 2005. Fisiologi Tumbuhan, Perkembangan Tumbuhan, dan Fisiologi Lingkungan. Institut Teknologi Bandung, Bandung, (In Indonesian).
15. Cruz, P., 1997. Effect of shade on the growth and mineral nutrition of a C4 perennial grass under field conditions. Plant Soil, 188: 227-237.
16. Wilson, J.R. and M.M. Ludlow, 1990. The environment and potensial growth of herbage under plantations. Proceedings of Workshop on Forages for Plantation Crops, June 27-29, 1990, Sanur, Bali, Indonesia, pp: 10-24.
17. Sanchez, P.A., 1976. Properties and Management of Soil in the Tropic. Jhon Wiley and Sons, New York, pp: 225-270.
18. Wong, C.C. and J.R. Wilson, 1980. Effects of shading on the growth and nitrogen content of green panic and Siratro in pure and mixed swards defoliated at two frequencies. Aust. J. Agric. Res., 31: 269-285.
19. Vanis, R.I.D., 2007. Pengaruh pemupukan dan interval defoliasi terhadap pertumbuhan dan produktivitas rumput gajah (*Pennisetum purpureum*) di bawah tegakan pohon sengon (*Paraserianthes falcataria*). Skripsi Fakultas Peternakan Institut Pertanian Bogor, Bogor.
20. Manggiring, W., N. Kurniawati and Priyadi, 2017. Production and quality *Pennisetum purpureum* at shading condition and nitrogen fertilizer dosage. J. Penelitian Pertanian Terapan, 17: 58-65.
21. Buckman, H.O. and N.C. Brady, 1982. Ilmu Tanah. Bharata Karya Aksara, Jakarta, (In Indonesian).
22. Gardner, F.P., R.B. Pearce and R.L. Mitchell, 1991. Physiology of Crop Plants. (Translate by H. Susilo). Universitas Indonesia Press, Jakarta.
23. Fitter, A.H. and R.K.M. Hay, 1991. Environmental Physiology of Plants. (Translate by Handayani, S., E.D. Purbayanti and B.S. Sandono). Universitas Gadjah Mada, Yogyakarta.
24. Rellam, C.R., S. Anis, A. Rumambi and Rustandi, 2017. The effect of shading and nitrogen fertilization on morphological characteristics of dwarf elephant grass (*Pennisetum purpureum* cv. Mott). J. Zootek, 37: 179-185.
25. Norton, B.W., J.R. Wilson, H.M. Shelton and K.D. Hill, 1991. The effect of shade on forage quality. Proceedings of Workshop on Forages for Plantation Crops, June 27-29, 1990, Sanur, Bali, Indonesia, pp: 83-88.
26. Wilson, J.R. and C.C. Wong, 1982. Effects of shade on some factors influencing nutritive quality of green panic and Siratro pastures. Aust. J. Agric. Res., 33: 937-949.
27. Hardjowigeno, S., 1995. Soil Science. Mediyatama Sarana Perkasa, Jakarta, (In Indonesian).
28. Suryana and Lugiyo, 2006. Effect of cutting intervals on the production of Sorghum CV Jumbo. National Technical Meeting Paper. Animal Research Institute, Bogor, (In Indonesian).
29. Salisbury, F.B. and C.W. Ross, 1991. Plant Phisiology. ITB., Bandung, (In Indonesian).
30. Bona, D. and F.A. Montteiro, 2010. The development and production of leaf and tillers by marundu palisadegrass ferthized with nitrogen and sulphur. Trop. Grasslands, 44: 192-201.
31. Fathul, F., Liman, N. Purwaningsih and S. Tantalo, 2014. Feed and Ration Formulation. Faculty of Agriculture, University of Lampung, Indonesia, (In Indonesian).