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# The Effects of Cutting Heights and Intervals of Defoliation on Productivity and Nutrient Content of *Brachiaria humidicola* (Rendle) Schweick

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## *ABSTRACT*

*The productivity of forage is strongly influenced by cutting height and interval of defoliation. Experiment was conducted at the Research Institute for Industrial Plants and Other Palm (BALITKA) Manado since June 2008 until April 2009. The objective of the experiment was to find out the effects of intensity and intervals of defoliation on dry weight production and the quality of nutrients. The experiment was arranged in factorial RCBD. The intensity of defoliation was based on cutting height, i.e. 5, 10, 15 cm, whereas the intervals of defoliation were 30, 45, 60 day and 456.54 Degree Days (DD). The data of dry weight production, leaf stem ratio, nutrient quality were collected. The results showed that there were significant effects of treatments on all parameters. Productivity of B. humidicola in terms of high dry weight yield, high leaf stem ratio and crude protein, low crude fiber and acid detergent fiber (ADF) content were found in the interaction of intensity 10 cm with the interval of defoliation among the vegetative development stage of 30 and 45 days, as well as the interval of defoliation based on heat unit accumulation of 456.54 DD. The research implies that a cutting height at 10 cm and interval of defoliation as mentioned above is ideal for B. humidicola. Utilization of growing degree days (GDD) to determine the appropriate time for defoliation is considerable under this experiment.*

*Keywords: B. humidicola, defoliation, forage, nutrient, productivity*

## *ABSTRAK*

*Produktivitas hijauan sangat dipengaruhi oleh tinggi dan interval waktu pemotongan. Percobaan ini dilaksanakan di lahan milik Balai Penelitian Kelapa dan Palma Lain (BALITKA) Manado. Tujuan percobaan ini adalah untuk mempelajari pengaruh intensitas dan interval pemotongan terhadap produksi bobot kering dan kualitas nutrien. Percobaan disusun secara faktorial dengan rancangan dasar acak kelompok. Faktor pertama adalah intensitas pemotongan berdasarkan tinggi pemotongan 5, 10 dan 15 cm di atas permukaan tanah, sedangkan faktor kedua adalah interval waktu pemotongan 30, 45 dan 60 hari, dan pada 456.54 DD. Hasil percobaan ini menunjukkan bahwa terdapat pengaruh nyata perlakuan terhadap semua peubah. Produktivitas B. humidicola dalam hal produksi bobot kering yang tinggi, rasio daun:batang dan protein kasar yang tinggi, kandungan serat kasar dan acid detergent fiber (ADF) yang rendah diperoleh pada interaksi intensitas pemotongan 10 cm dengan interval pemotongan 30, 45 hari, demikian juga pada interval pemotongan yang didasarkan pada akumulasi satuan bahang 456.54 DD. Hasil percobaan ini menunjukkan bahwa tinggi pemotongan 10 cm dan interval defoliasi tersebut di atas adalah ideal untuk B. humidicola. Penggunaan satuan bahang atau growing degree days (GDD) untuk menetapkan waktu yang tepat untuk pemotongan dapat dipertimbangkan.*

*Kata kunci: B. humidicola, defoliasi, hijauan pakan, kualitas, produktivitas*

## INTRODUCTION

*Brachiaria humidicola* (Rendle) Schweick is one of the perennial grasses, with creeping growing habits, stoloniferous and rhizomatous, outstanding agronomic characteristics, well adapted to shade environment such as underneath mature coconut trees. Defoliation is simply defined as taking out part of a plant through cutting or grazing by herbivore animals, but actually it involves a good understanding of the interrelation between foraging, soil and herbivores (Gorder *et al*., 2005). Defoliation intensity

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(cutting height) and frequency varies according to cutting methods and the types of animals grazing. Severe intensity of defoliation leads to nitrogen and energy allocation from roots to the growing leaves, consequently, suppressed root growth (Lestienne *et al*., 2006). The ability of forages to grow and produce biomass depends on the interactions between plant genetics and environmental factors which also influences the physiological process. The results could be measured by analyzing morphological characteristics of the plants (Smart *et al*., 2001).

When the grasses defoliate, the plant directly releases carbon into the rhizosphere throughout the root exudates which provided nutrients for the prolification of soil micro organisms, which in turn accelerates the decomposition process of the soil's organic matter to fulfill the nutrient needs of the plants (Manske, 2003; Gorder *et al.,* 2005). This carbon translocation occurs fast, in a couple of hours, to maintain the carbon content in the plant equally both below and above ground (Kuzyakov, 2002).

The ability of forages to grow and produce biomass also depends on environmental factors, such as temperature (Duru and Ducrocq, 2000; Mitchell *et al*., 2001). Since air temperature varies during growing seasons, the calculation of calendar days to determine the harvesting time has a potential error of 10 days, but using the growing degree days (GDD) the error is minimized to 2 to 3 days (Miller *et al.,* 2001). Those could affect the accumulation of assimilates in the plant before defoliation, especially when the air temperature varies during the phase of growth and development of grasses due to changes of air temperature. The ability of grasses to regrowth after defoliation is determined by the carbohydrate reserve and depends on the optimal phenological development of plants which usually varies with each plant. Manske (2003) states that those optimum stages of development is when it has 3.5 mature leaves. Previous studies showed that to produce one new mature leaf of *B. humidicola* grown under coconut trees required 130.44 DD.

The objective of the experiment was to find out the effects of the cutting height and interval of defoliation on dry weight production, leaf stem ratio, and quality of nutrients.

## MATERIALS AND METHODS

The experiment was conducted at the Research Institute for Industrial Plants and Other Palms (BALITKA) Manado, from October 2008 to April 2009. *B.humidicola* were established using vegetative materials and planted in 30 x 30 cm spacing. Minor deficiencies of soil nitrogen, phosphorus and potassium were corrected by fertilizer application at the beginning of the experiment with Urea at 150 kg ha$^{-1}$, TSP 75 kg ha$^{-1}$ and KCl 75 kg ha$^{-1}$. The experiment was conducted under uniform stands of tall varieties of coconuts, 45 years old, planted in a square pattern at 10 m spacings. Light transmission at the site under mature tall coconuts averaged 73% at 10.00 a.m. on a sunny day. The maximum and minimum air temperatures were measured with te Model Weather Guide™ System, Taylor Precision Product, Oak Brook, IL 60523. A thermometer was placed above the canopy of grasses and recorded in the morning at 6.00 to 7.00 AM and in the afternoon at 5.00 to 6.00 PM.

There were three levels of cutting heights or intensities of defoliations (I) at 5 ($I_1$), 10 ($I_2$) and 15 cm ($I_3$) and three intervals of defoliations namely the ages of re-growth, based on 30 ($F_1$), 45 ($F_2$) and 60 ($F_3$) calendar days, and based on heat unit accumulation at 456.54 ($F_4$). A 456.54 DD was calculated from a heat unit needed to produce one mature leaf (206.61 DD) multiplied by 3.5 mature leaves (Miller *et al.,* 2001) as an ideal stage of growth for grazing (Manske, 2003). The accumulation of heat unit during the period of evaluation was calculated based on the formula: $GDD = \Sigma\ [(T.\ max + T.\ min)/2 - T\ base]$ (Miller *et al*., 2001). All treatments were put in a factorial arrangement based on randomized block design with three replications.

There were 36 plots of 3 m x 2 m, which were prepared by remove existing vegetation with the herbicide with the active ingredient of Glifosat 480 g L$^{-1}$ for grasses and combined with the active ingredient of 2,4-D 686 g L$^{-1}$ for broad leaf weeds, as well as removing dead material, ploughing and harrowing. Plots were weeded during the established periods, clearing by cutting was done after 60 days to get a uniform growth. At 30 days of growth, the $F_1$ treated were harvested followed by the other treatments of $F_2$ and $F_3$, while the $F_4$ were harvested when the accumulation of heat units reached 456.54 DD. A square of a 0.5 m x 1.0 m was used to sample the center of the plots leaving a 0.5 m border, to measure the yield of green biomass at the cutting height treatment. Samples (500 g) were separated in to the leaf and the stem components, and 1,000 g samples were collected for laboratory analysis. Samples were put in paper bags, labelled, sun dried and finally put in an oven at 70 $^oC$ for 24 hours to obtain the dry weight: crude protein, and crude fiber (AOAC, 1990), and for the neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents (Van Soest and Robertson, 1985).

## RESULTS AND DISCUSSIONS

Analysis of variance showed that the dry weight yield, leaf stem ratio, and nutrient content of forages were effected significantly by the cutting height and the frequency of defoliation. Furthermore, the interaction of both treatments significantly affected all variables measured (Table 1). These interactions showed that there were interdependent synergisms at certain levels of both treatments on the production and nutrient content of forages.

### *Productivity*

Even though the effects of treatments on dry weight, at period I, were not significantly different (Table 2), longer interval of defoliation produced more biomass compared to shorter interval. At period II, the highest dry weight yielded 251.46 g m$^{-2}$ which was found at the cutting height at 10 cm which interacted with the interval of defoliation of 456.54 DD. This was the only interaction producing high

Table 1. Analysis of variance recapitulation of the effects of cutting height and frequency of defoliation on the productivity and quality of *B. humidicola*

| Parameter | Cutting height | Defoliation intervals | Interaction of both treatment factors |
|---|---|---|---|
| Forages productivity | | | |
| Dry weight (g $m^{-2}$) | | | |
| - Period I | * | * | * |
| - Period II | * | * | * |
| Leaf:Stem Ratio | | | |
| - Period I | ** | * | * |
| - Period II | * | ** | * |
| Forages Quality | | | |
| Crude Protein (%) | ** | ** | * |
| Crude Fiber (%) | * | * | * |
| Neutral detergent fiber (%) | * | * | * |
| Acid detergent fiber (%) | * | * | * |

Note: * = significant; ** = highly significant

Table 2. The interaction effects of cutting height and interval of defoliation on dry weight (g $m^{-2}$)

| Cutting height | Defoliation intervals | | | |
|---|---|---|---|---|
| | 30 days | 45 days | 60 days | 723 DD |
| Period I | | | | |
| 5 cm | 205.06b | 225.33ab | 249.80a | 215.13ab |
| 10 cm | 213.80ab | 230.26ab | 223.00ab | 241.66a |
| 15 cm | 182.46b | 222.00ab | 240.53a | 217.50ab |
| Period II | | | | |
| 5 cm | 174.50c | 217.26b | 225.93ab | 208.00bc |
| 10 cm | 185.26bc | 225.33ab | 241.06ab | 251.46a |
| 15 cm | 189.06bc | 224.60ab | 240.40ab | 204.66bc |

Note: Numbers in columns and rows each period followed by different letter is significantly different by HSD at $\alpha = 0.05$

dry weight constantly in both periods of evaluations. This result is probably due to the availability of vigorous growing points at stubble heights of 10 cm as well being found in others forage grasses and has its optimum energy reserved for growth after defoliation (Wijitphan *et al*., 2009). That treatment did not work alone but further it was induced strongly by the stages of development of grass at 456.54 DD, which is probably in the optimal vegetative phase of development. Miller *et al.* (2001) stated that the bias of using DD to determine the date of harvesting is only a 2 to 3 day error compared to a 10 day error measured in calendar days.

*Leaf:Stem Ratio*

Leaf:stem ratio is one of the criteria to evaluate forage species as animal feed. At period I, the interaction of interval defoliation at 30 days with cutting heights of 5 , 10 and 15 cm consecutively produced leaf stem ratio of 1.44, 1.40 and 1.48 (Table 3). These values were significantly higher compared with 0.87, 0.87 and 1.03 produced from the interactions of all cutting heights with interval of defoliation at 60 days. High leaf:stem ratios, in all cutting heights, was mostly influenced by the defoliation interval at 30 days, where at this stage of vegetative development it usually has a high leaf proportion (McMaster *et al.,* 2003). On the contrary, low leaf:stem ratios in all cutting heights interact with the interval of defoliation at 60 day. This is probably due to the stage of the development of grass which already passed the vegetative development stage and which is high in stem components because the stem in *B.humidicola* increased linearly (Chobtang *et al.,* 2008). Furthermore at those stages of development some layers of leaves below the canopy received limited light, which induced the reduction of the photosynthetic rate of those leaves (Raden *et al*., 2008). At period II, a higher leaf stem ratio was found in all cutting heights interacting with the interval of defoliation $F_1$ and $F_2$, and significantly higher

Table 3. The interaction effects of cutting height and interval of defoliation on leaf stem ratio

| Cutting height | Defoliation intervals | | | |
|---|---|---|---|---|
| | 30 days | 45 days | 60 days | 723 DD |
| Period I | | | | |
| 5 cm | 1.44a | 0.96bc | 0.87c | 1.14bc |
| 10 cm | 1.40ab | 1.37ab | 0.87c | 1.40ab |
| 15 cm | 1.48a | 1.08bc | 1.03bc | 1.30ab |
| Period II | | | | |
| 5 cm | 1.59a | 1.40a | 1.10b | 1.29ab |
| 10 cm | 1.59a | 1.39a | 1.02b | 1.39a |
| 15 cm | 1.50a | 1.35a | 1.07b | 1.30ab |

Note: Numbers in columns and rows each period followed by different letter is significantly different by HSD at $\alpha = 0.05$

leaf stem ratio was produced by interaction with $F_3$, but not different when interacting with $F_4$. These results could explain that this grass responded positively to all treatments, and showed their ability to persist through the mechanism of adaptation on defoliation pressure.

*Crude Protein*

The lowest protein content, 7.88%, was found in the interaction of the cutting height at 15 cm, with 60 days interval of defoliation (Table 4). High crude protein content at those interactions were dominated by 5 cm and 10 cm cutting heights interacting with defoliation interval at 30 and 45 days, and also by the accumulation of heat units at 456.54 DD. This result indicates that heat unit accumulations of 456.54 DD allowed *B.humidicola* to produce crude protein similar to those at 30 and 45 days. Besides defoliation interval, other factors influences cutting height defoliation at 5 cm and 10 cm to maintain a higher level of crude protein especially interacting with the interval of defoliation 30, 45 days and 456.54 DD, except the interval of defoliation at 60 days. Further, lower CP in the high cutting height of defoliation because of the use of ground tillers was reduced although these new shoots are usually leafy and nutritious (Smart *et al.,* 2001). In recent studies of tropical grasses, a strong relationship has been found between canopy height and light interception on the pasture, and hence the dynamics of accumulation of dry matter, suggest that grass height can be a reliable criterion for determining the appropriate time to reintroduce animals in rotational grazing systems (DaCunha *et al.,* 2010). Nevertheless, the crude protein content in this experiment is enough to fulfill the needs of 7% to 8% of crude protein to support the optimal activity of the rumen microbes in the digestion process of crude fiber to produce volatile fatty acids consisting of acetate, propionate and butyric acids as the main sources of energy for ruminant animals (Coleman *et al.,* 2003)

*Crude Fibre*

The crude fibre content of grasses is usually related with the ages of plants which is tend to increas when the plant gets old. The crude fibre component increases abundantly as the major component found in forage cell walls which contain cellulose, hemicellulose and lignin. Crude fibre increased following the defoliation time which was delayed from 30 days to 45 days and 60 days especialy when these intervals of defoliations interacted with cutting heights at 15 cm at 34.15% and 34.62%. These results were significantly higher than all interactions, except with combination of 15 cm and 456.54 DD (33.40%). Meanwhile, the lowest crude fibre content was found at interaction 5 cm and 456.54 DD (31.39%) and no significant difference with the other interactions, but significantly lower compared to the interactions of 15 cm and 45 days, 65 days, or 456.54 DD as depicted on Table 5. This might be due to the penetration of light reaching the lower part of plant which was limited because mulch covered soil surface, thus lead to reduced soil temperature and inhibited the apperance of new vigorous ground tillers and the quality (McMaster *et al.,* 2003).

Table 4. The interaction effects of cutting height and frequency interval of defoliation on crude protein content (%)

| Cutting height | Defoliation intervals | | | |
|---|---|---|---|---|
| | 30 days | 45 days | 60 days | 723 DD |
| 5 cm | 10.74a | 10.55a | 9.63ab | 11.01a |
| 10 cm | 10.91a | 10.56a | 9.26ab | 10.63a |
| 15 cm | 9.23ab | 8.91ab | 7.88b | 8.68ab |

Note: Numbers in columns and rows each period followed by different letter is significantly different by HSD at $\alpha = 0.05$

*Neutral Detergent Fibre (NDF)*

Neutral detergent fiber is a part of crude fibres, rich in hemicellulose which is digestible. Table 6 showed that a low in NDF content was found at the interaction of a cutting height of 5 cm with all frequencies of defoliations, and the lowest was 6.60% ($I_1F_2$), which is significantly lower than 68.23% ($I_2F_3$), 68.40% ($I_2F_4$) and 68.08% ($I_3F_3$). The average of NDF content in this experiment was still in the range of 65.70% among the tropical grasses (Coleman *et al.,* 2003).

*Acid Detergent Fibre (ADF)*

The highest content of ADF was found in the interval of defoliation at 60 days interacting with cutting height of defoliation at 15 cm (Table 7). The lowest ADF content was found at a cutting height of 5 cm interacting with interval of defoliation at 30 and 45 days, and with the accumulation of heat unit of 456,54 DD. Furthermore the same result was found at interaction of cutting height at 10 cm and interval of defoliation based on the accumulation of heat unit. These results means that the lower of cutting height the lower ADF content, except the interval of defoliation based on the accumulation of heat unit of 456,54 DD. The ADF value in this experiment was comparable with in average ADF content commonly found in tropical grasses (Coleman *et al.,* 2003).

All variables measured in this experiment were a part of the evaluation of forages for animal feed. The leaf stem: ratio has a special value since it could result in a quality of forages needed by ruminant animals. From a biomass point of view, the higher dry weight production was dominated by a interval defoliation at 45 and 60 days, and 456.54 DD ($F_4$) interacting with all cutting height of defoliation in both periods of evaluation. By contrast, the leaf:stem ratio decreased significantly when the age of plant increased as the interval of defoliation was delayed from 30 days up to 60 days in both periods, but surprisingly this ratio increased at treatment of 456.54 DD for both periods. This results explain that using degree days is more precise to determine the appropriate time for defoliation in which the plant is still in the vegetative stage of growth. To provide a good quality of feed, it could be expected from the forages with high crude protein and low crude fiber, and NDF should be higher than the ADF contents. The crude protein content was generally good in all interactions, except at 15 cm cutting height with defoliation interval of 60 days.

Table 5. The interaction effects of cutting height and interval of defoliation on crude fiber content (%)

| Cutting height | Defoliation intervals | | | |
|---|---|---|---|---|
| | 30 days | 45 days | 60 days | 723 DD |
| 5 cm | 32.24bc | 32.23bc | 32.45bc | 31.39c |
| 10 cm | 32.59bc | 32.23bc | 33.18b | 32.10bc |
| 15 cm | 33.17b | 34.15a | 34.62a | 33.40ab |

Note: Numbers in columns and rows each period followed by different letter is significantly different by HSD at $\alpha = 0.05$

Table 6. The interaction effects of cutting height and interval of defoliation on NDF content

| Cutting height | Defoliation intervals | | | |
|---|---|---|---|---|
| | 30 days | 45 days | 60 days | 723 DD |
| 5 cm | 66.25bc | 65.60c | 66.37bc | 66.65bc |
| 10 cm | 68.05ab | 67.97ab | 68.23a | 68.40a |
| 15 cm | 66.36b | 67.35b | 68.08a | 67.39b |

Note: Numbers in columns and rows each period followed by different letter is significantly different by HSD at $\alpha = 0.05$

Table 7. The interaction effects of cutting height and interval of defoliation on ADF content (%)

| Cutting height | Defoliation intervals | | | |
|---|---|---|---|---|
| | 30 days | 45 days | 60 days | 723 DD |
| 5 cm | 34.78c | 34.50c | 37.57b | 34.71c |
| 10 cm | 36.63b | 37.48b | 38.42ab | 35.02c |
| 15 cm | 36.86b | 37.10b | 39.36a | 36.55b |

Note: Numbers in columns and rows each period followed by different letter is significantly different by HSD at $\alpha = 0.05$

## CONCLUSION

The interaction of cutting height and interval of defoliation significantly affected productivity and quality of *B. humidicola.* The best productivity and quality of forages in the case of dry weight yield, leaf stem ratio, crude protein, crude fiber, neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were found in the combination of an ideal cutting height of 10 cm and defoliation interval of 30 days up to 45 days. Heat unit 723 DD could be considered to determine the appropriate time for defoliation.

## REFERENCE

Association of Official Analytical Chemists (AOAC). 1990. Official Method of Analysis. 115th Ed. AOAC, Washington DC.

Coleman, S.W., S.P. Hart, T. Sahlu. 2003. Relationship among forage chemistry, rumination and retention time with intake and digestibility of hay by goats. Small Rum. Res. 50:129-140.

Chobtang, J., S. Prajakboonjetsada, S. Watananawin, A. Isuwan. 2008. Change in dry matter and nutritive composition of *Brachiaria humidicola* grown in Ban Thon soil series. Mj. Int. J. Sci. Tech. 2:551-558.

DaCunha, B.A.L., D. Nascimento, M.T.C. Da Silveira, D.B. Montagner, C.S. Rodrigues, K.S. Pena, W.L. Silva. 2010. Effecs of two grazing heights on morphogenic and structural characteristics of guinea grass under rotational grazing. Trop. Grasslands 44:253-259.

.

Duru, M., H. Ducrocq. 2000. Growth and senescence of the succesive grass leaves on a tiller. Ontogenic development and effect of temperature. Ann. Bot. 85:635-643.

Gorder, M.M., L.L. Manske, T.L. Stroh. 2005. Grazing Treatment Effects on Vegetative Tillering and Soil Rhizospheres of Western Wheatgrass. Annual Report of Dickinson Research Extention Center. DREC, North Dakota.

Kuzyakov, Y. 2002. Factor affecting rhizosphere priming effects. J. Plant Nutr. Soil Sci. 165:382-396.

Lestienne, F., B. Thorton, F. Gastal. 2006. Impact of defoliation intensity and frequency on N uptake and mobilization in *Lolium perenne.* J. Exp. Bot. 57: 997-1006.

Miller, P., W. Lanier, S. Bandt. 2001. Using Growing Degree Days to Predict Plant Stages. Extension Service Montana State University, Montana.

Manske, L.L. 2003**.** Effect of grazing management treatment on rangeland *vegetati*on. Summary Range Research Report of Dickinson Research Extention Center. DREC, North Dakota.

McMaster, G.S., W.W. Wilhelm, D.B Palig, J.R. Porter, P.D. Jamieson. 2003**.** Spring wheat leaf appearance and temperature: extending the paradigm?. Ann. Bot. 91:697-705.

Mitchell, R., J. Fritz, K. Moore, L. Moser, K. Vogel, D. Wester. 2001. Predicting forages quality in switchgrass and big bluestem. Agron. J. 3:118-124.

Raden, I., B.S. Purwoko, Hariyadi, M. Ghulamahdi, E. Santosa. 2008. Leaf characteristic of *Jatropha curccas* L. and Its relation to photosynthesis. Bul. Agron. 36:167-174.

Smart, A.J., W.H. Schacht, L.W. Moser. 2001. Predicting leaf/stem ratio and nutritive value in grazed and nongrazed Big Bluestem. Agron. J. 93:1243-1249.

Van Soest, J.P., J.B. Robertson. 1985. Analysis of Forages and Fibrous Foods. A Laboratory Manual for Animal Science. Cornell University, New York.

Wijitphan, S., P. Lorwilai, C. Arkaseang. 2009. Effect of cutting heights on productivity and quality of Napier Grass under irrigation. Pak. J. Nutr. 8:1244-1250.