Effect of the different clipping time on the yield and quality of dwarf napiergrass on marginal land under manure application

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Abstract. The effect of the different clipping time on the yield and quality of Dwarf Napiergrass under manure application were investigated in this experiment. In relation to plant growth and quality, the needs of grassland for fertilizer nutrients are influenced by the intensity of management, by whether the forage crop is harvested by clipping and the botanical composition of the forage crop. Manure contains essential plant nutrients and to use as a soil amendment for crop production is a practical method, so as to solve the disposal problem of livestock. Dwarf napiergrass as a perennial summer crop under the blocked design with 2 plants m⁻² were applied to 3 levels of manure and 4 clipping times. The manure revealed so effective fertilizer to increase dry matter yield, and forage quality, especially in crude protein content and in vitro dry matter digestibility (IVDMD) at the same clipping time with the increase in manure application level.

1. Introduction

Animal manure contains important nutrients and organic matter that can be used as a nutritional origin for forage to produce high yield, nutritive value and adequate environment of grassland farming. Livestock waste can be processed to manure by a practical method, which requires crops to use these nutrients efficiently. To manage grassland systems intensively requires sizeable amount of N fertilizer to sustain high pasture dry matter yield and nutritive value. Defoliation is a valuable factor because of the multiple effect on the growth characters as well as forage qualities, either by cutting or by grazing animals [1,2].

Dwarf varieties introduced from Thailand were different from normal varieties in tiller number, mean tiller weight and percentage of leaf blade as a preliminary study in an established year. Napiergrass (dwarf-late, DL) is a tropical grass, with a perennial habit in the low-altitudinal sites and has a high animal performance for the beef cows under the rotational grazing in southern Kyushu of Japan [3], and can be also adapted to the rotational grazing use by dairy cows in Miyazaki City, southern Kyushu [4,5]. Several studies have been done to evaluate the effect of fertilization on yield and quality of napiergrass [5-7], there is limited comparative studies on application of fertilizers from solid manure, chemical and especially effluent from biogas plant to dwarf napiergrass pasture. DL
napiergrass have been evaluated under different levels of manure application to examine the potential for quality herbage production and nutrient capture. Thus, this study was evaluated for the response of DL napiergrass to 3 levels of manure application by dry matter yield (DMY), crude protein (CP) content, and in vitro dry matter digestibility (IVDMD) contents of herbage under cut-and-carry system for first year after establishment.

2. Materials and methods

2.1. Plant culture
The experiment was conducted in an experimental field, at Galung village, Barru sub-distric, Barru district South Sulawesi Province under natural conditions. The DL napiergrass was grown by transplanting a stem cutting with 2 plants m\(^{-2}\) on November 10, 2017.

2.2. Experimental design
The plots were set into a randomized blocked design by 3 replications and were applied into 4 treatments, which have 3 levels of manure application. The manure was additionally applied to DL napiergrass in the split application.

2.3. Fertilizer application
Application of manure was 3 levels at 4.67, 2.88, 1.38, and 0.00 g N m\(^{-2}\) time\(^{-1}\) for high (H), medium (M), low (L) and control (C) levels, respectively. Application to DL napiergrass was conducted every month at 5 times from May to September.

2.4. Chemical analysis of plant
Protein nitrogen contents of plant of each plant organs (LB and ST) at each cutting were determined by Kjeldahl Digestion method. The IVDMD is a laboratory test used as a plant quality index for animal feed by animal nutritionists [8]. The method includes two consecutive digestion phases. At the time first digestion phase in this study, plant materials were incubated under anaerobic conditions with rumen microorganisms for 48 hours at 39°C. This was followed by a 24 hours acid-pepsin digestion phase at 39°C, under anaerobic conditions. Following these 72 hours incubation, residual plant components were collected and oven dried (105°C for 12 hours).

3. Results and discussion

3.1. Dry matter yield and crude protein content in DL napiergrass
Both of DMY and CP content in DL napiergrass increased unquestionable with the increase in manure level across all clipping times (table 1).

Napiergrass can be intercropped with herbaceous crops as a pure stand and when it was cultivated in the combination of leguminous tree crops, total dry matter yield (DMY) and nutritive value increased [9]. DL napiergrass proved to be satisfactory that annual total yield increased from 765.54 (L level) to 3375.45 (H level) g DM m\(^{-2}\) by 64-72% across 3 manure treatments, as indicated in Table 1. The increase in annual DMY from the L level to H Level was brought about by the increase in nitrogen level. It is a common feature that annual DMY increased with the increased manure application level in napiergrass [3,10,11] as well as others tropical grasses [12], if pasture management was suitable for grasses.

Annual total of DMY and CP increased from the L level to H level. The differences in DMY among plots were significant in every clipping time. Annual total DMY was positively and linearly regressed with annual total of N input (r = 0.971, P < 0.05 as shown in figure 1. Correlation coefficient of DMY with CP content was significantly positive at the 1% level (table 2).
Table 1. Changes end yield and crude protein in dwarf napiergrass pasture in 2018.

| Clipping Time and date | Dry matter yield (gm⁻²) | Crude Protein (%) | Treatment† | Treatment† |
|------------------------|-------------------------|-------------------|------------|------------|
|                        | C          | L          | M          | H          | C          | L          | M          | H          |
| I (February 22)        | 125.83c†† | 192.63c    | 540.18b    | 1470.00a   | 8.2d       | 8.9c       | 12.3b      | 14.2a      |
| II (May 10)            | 52.33d    | 206.98c    | 376.78b    | 673.68a    | 8.5d       | 9.3c       | 12.7b      | 14.4a      |
| III (July 26)          | 111.02d   | 258.31c    | 384.21b    | 752.66a    | 8.7d       | 9.5c       | 13.1b      | 14.7a      |
| IV (October 10)        | 49.93c    | 107.62c    | 285.10b    | 479.12d    | 8.8d       | 9.9c       | 13.3b      | 14.8a      |
| Annual total/Mean      | 339.12    | 765.54     | 1586.28    | 3375.45    | 8.5        | 9.4        | 12.9       | 14.5       |

†Manure application of C level (0.00g N m⁻² time⁻¹), L level (1.38 g N m⁻² time⁻¹), M level (2.88 g N m⁻² time⁻¹), H level (4.67g N m⁻² time⁻¹).
††Symbols with different letters in a row denote significant different for yield or crude protein among treatments on the same date at the 5% level. Ns : non-significant (P>0.05).

Table 2. Correlation coefficient of dry matter yield (DMY) with crude protein (CP) content and in vitro dry matter digestibility (IVDMD).

| Species       | DMY | CP  | IVDMD |
|---------------|-----|-----|-------|
| Napiergrass   |     |     |       |
| (n=16)        |     | 0.743**† |       |
|               |     | 0.269†  | 0.264** |

†Intra-day repeatability was estimated by analysis of four replicate samples at three concentration levels on the same day. †*, †**, **: Significant at the 10%, 5% and 1% level, respectively.

3.2. Nutritive value

The changes in IVDMD for leaf blade (LB) and stem inclusive of sheath (ST) in DL napiergrass were shown in Figure 2 at each clipping time. IVDMD of LB maintained above 60% and that of ST almost above 70%. The clear response in IVDMD to the increase in manure application rate was not certain among treatments (Fig. 2).

Chemical compositions, especially IVDMD and CP content, better options for feeding herbage to cattle in silvopastoral systems. [13] reported that the wide spread of IVDMD in 41-60% from raw herbage materials reduced to that in 60-69% by 10% of chemical base (NaOH) treatment. In this research, IVDMD preserved above 60%, and stem inclusive of leaf sheath was always higher in IVDMD than in leaf blade. As the minimum CP requirement for livestock production is 6-8%, annual average of CP content maintained satisfactory level under the examined manure levels, ranging in 8.2-14.8% across manure-supplied. Thus, based on IVDMD and CP content, herbage-cropping system can produce competently quality herbage to cattle feeding.
Figure 1. Relationship between annual total of dry matter yield (DMY) and annual total of N input in 2018. Treatment: Manure application of C, L, M, H level (0.00 (▲), (1.38 (■), 2.88 (●), 4.67 (○) g N m^{-2} time^{-1}, respectively).

\[ y = 130.1x + 65.359 \]
\[ R^2 = 0.9421 \]
\[ r = 0.971 \ (P < 0.05) \]

Figure 2. Change in in vitro dry matter digestibility (IVDMD) of herbage with cutting under different treatments. For the treatments, refer to Figure 1. LB: leaf blade, ST: stem inclusive of leaf sheath, LB+ST: leaf blade and stem inclusive of leaf sheath. Symbols with different letters denote significant difference in each organ among treatments on the same date at 5% level. ns : P > 0.05.

The variation in IVDMD was related with that in dry matter yield and CP content as shown in table 2. The positive interrelations of IVDMD with CP content were clearly significant at the 1% level, while there was a negative correlation of IVDMD with dry matter yield at the 10% level (table 2).

In general, CP content is affected by direct and indirect factors with the application of fertilizer, such as manure. The former direct factor appears rapidly in forages after the supply of fertilizer,
especially liquid form of manure, in accordance with the change of leaf color to become dense green. The latter indirect factor is mainly attributable to dilution of CP content by the rapid accumulation of cell wall carbohydrates at the latter stages of growth [14], which appeared typically in the first-cut due to the heavy accumulation of biomass (Table 1). One of the other indirect factors is the change of leaf percentage with advance in growth stage. It is a continual phenomenon in napiergrass that CP content is higher in the early growth stage than in the late and senescent stage in Africa [15-16]. The optimal temperature for growth in napiergrass is 25 – 40 °C and its growth ceases when temperature falls below 10 °C [17]. Under the sub-optimal temperature below 25 °C, stem elongation of napiergrass is suppressed severely, causing the higher leaf percentage to lead to the increase in CP content (table 1).

4. Conclusion
The application of manure to DL napiergrass production system had a proportionate effect on herbage yield and quality, and manure has a positively linear effect on enhancing dry matter production within the examined level of 20 g N m$^{-2}$.

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