ネピアグラスの乾物収量とin vitro乾物消化率に対する堆肥施用の後作用

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After-effect of Manure Application on Dry Matter Yield and *in vitro* Dry Matter Digestibility of Napiergrass (*Pennisetum purpureum* Schumach)

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Summary : After-effects of manure application on dry matter yield and *in vitro* dry matter digestibility (IVDMD) of napiergrass (*Pennisetum purpureum* Schumach) were evaluated by growth characters (dry matter weight and leaf area) and IVDMD under the twice-cutting and no fertilization at the third year, following 3 cutting regimes and 3 levels of manure application in the former 2 years. Dry matter yield, total nitrogen absorption of herbage and *in vitro* digestible dry matter yield increased with the increase in manure application and with the decrease in cutting frequency. Nitrogen use efficiency of the applied manure for 3 years of experiment decreased with the increase in manure application and cutting frequency.

Key words : After-effect, Dry matter yield, *In vitro* dry matter digestibility, Manure, Napiergrass

Introduction

Napiergrass (*Pennisetum purpureum* Schumach) can exhibit high dry matter productivity similarly among several areas in the southern part of Japan (Ito *et al.* 1988; Matsuda *et al.* 1991), and plant physiological bases of high productivity in napiergrass were analyzed by its high response to the increase in fertilization (Woodard and Prine 1991 ; Sunusi *et al.* 1997, 1999 ; Ishii *et al.* 1999 ; Wadi *et al.* 2003). From our previous studies, napiergrass absorbed less than half of nitrogen content in manure at the applied year under the field (Sunusi *et al.* 1997) and pot conditions (Idota *et al.* 2005). The mineralization of organic fertilizer is usually slow and might tend to be insufficient for the early growth of plants due to the low temperature condition in spring. The extent of unabsorbed nitrogen from the applied manure should be examined in the following year, so as to estimate the sustainable manure management for napiergrass cultivation. Crude protein content and digestibility of napiergrass were affected positively by manure application (Woodard and Prine 1991 ; Sunusi *et al.* 1997), while sometimes digestibility was affected negatively by manure application due to stem hardening in napiergrass (Miyagi 1981). Cutting frequency showed the prominent effect on the yield and digestibility of napiergrass at the applied year (Mohammad *et al.* 1988 ; Hsu *et al.* 1989 ; Hassan *et al.* 1990 ; Woodard and Prine 1991), while the after-effect of cutting frequency on the growth of napiergrass in the following year was limitedly informed (Hassan *et al.* 1990 ; Woodard and Prine 1991).

Thus, the present study examined the after-effect of manure application on dry matter yield and digestibility at the third year of establishment, following 3 cutting regimes and 3 levels of manure application in the former 2 years.

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Materials and Methods

Plant culture and treatments

The experiment was carried out in the experimental field of Faculty of Agriculture, University of Miyazaki in 1995. Plant spacing of napiergrass (*Pennisetum purpureum* Schumach, cv. Wruk wona) was 50 cm×50 cm and plant density was 4 plants/m^2 at the establishment in 1993. Napiergrass stand regrown from stubbles at the third year of establishment was used for the present experiment. The overwintered stubbles of plants were grown without fertilization in 1995, following 3 levels of cutting frequency and 3 levels of manure application in 1993 and 1994. Plot size for each treatment was 5 m×5 m (25 m^2) without replication. Plants were cut at the height of 15 cm above the ground surface on August 1 and November 11, 1995.

The two-years' totals of manure application (fresh weight basis) in 1993 and 1994 were 730 ton/ha (490+240 ton/ha), 370 ton/ha (250+120 ton/ha) and 10 ton/ha (10+0 ton/ha) for high (H-level), medium (M-level) and low (L-level), respectively. Total nitrogen (TN) contents of applied manure were 3362, 1700 and 38 kg/ha for the H-, M- and L-level, respectively. Three cutting frequencies in 1994 were one-, three- and six-times cutting per year, those were abbreviated as C1, C3 and C6, respectively for each of manure application level.

Plant growth measurements

Dry matter weight (DMW) of each plant part and some plant characters relating to dry matter production were measured for 16 plants at every cutting time of each plot. Plants of the herbage part were divided into leaf blade (LB), stem with leaf sheath (ST) and dead part (D) and measured for DMW of each organ after being oven-dried at 72 ℃ for 72 hrs. Leaf area of the herbage part was measured by leaf area meter (AAM-8, Hayashi Denko Co. Ltd.).

Measurements of herbage digestibility, digestible yield and nitrogen concentration

The IVDMDs of LB and ST in the herbage part at both the first and second cuttings were determined by the pepsin-cellulase digestion method (Goto and Minson 1977) by 3 replications. Total *in vitro* digestible dry matter yield (TIVDDMY) of herbage part was calculated by the product of DMY with IVDMD. The TN concentrations of LB and ST were determined by the indophenol method following the Kjeldahl resolution of salicylic acid-sulfuric acid solution (Method of Plant Nutrition Experiment Commit-tee, 1990) by 3 replications.

Input, output and residual total nitrogen

Input of TN was supplied by manure application in 1993 and 1994. Output of TN was calculated by the total nitrogen absorption (TNA) of the herbage part in 1993-1995. Residual TN in 1995 was calculated by the difference between input and output of TN.

Nitrogen use efficiency for 3 years of experiment was calculated by the percentage of outputted TN relative to inputted TN.

Results and Discussion

Climatic conditions

Changes in daily mean temperature, daily total of solar radiation and precipitation at ten-day's interval in 1995 and in the averaged year were shown in Fig. 1. Both air temperature and solar radiation in July and August were higher in 1995 than in the averaged year, while precipitation from mid-July to mid-September was extremely lower at 17 % as in the averaged year. Thus, the climate at the experiment year was hot and sunny but dry in the summer season.

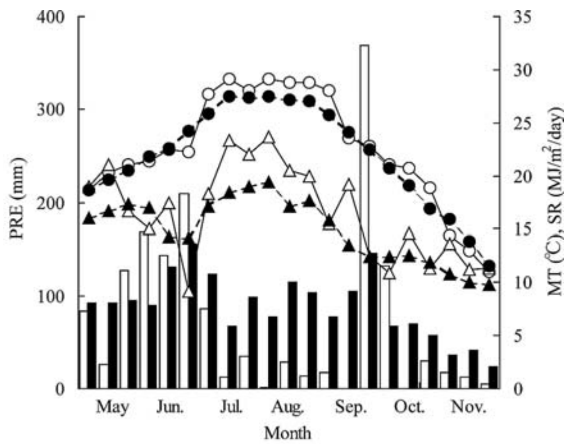

Fig. 1. Changes in ten day's average of mean air temperature (MT ; ○, ●), total solar radiation (SR ; △, ▲) and ten day's total of precipitation (PRE ; □, ■) in 1995.
Open symbols : 1995, closed symbols : averaged year (mean of 30 years in 1971-2000).

Changes in dry matter yield, nitrogen absorption and *in vitro* digestible dry matter yield

Figure 2 shows the changes in the herbage dry matter yield (DMY) in 1995 (DMY_{1995}) and the ratio of DMY in 1995 to that in 1994 ($DMY_{1995/1994}$), as affected by the cutting frequency and manure application level in the previous year (1994). The DMY_{1995} increased with the increase in manure application and with the decrease in cutting frequency. DMY at the first and second cutting was correlated closely with leaf area index, including all cutting frequencies and manure application levels ($r=0.986$, $P<0.001$). The $DMY_{1995/1994}$ was correlated positively with DMY_{1995} ($r=0.897$, $P<0.01$), and DMY_{1995} was higher at 1.3-1.7 times than the herbage DMY in 1994 at the cutting frequency of C1 in every manure application level. On the other hand, DMY_{1995} was suppressed at 22-53 % as DMY in 1994 at the cutting frequencies of C3 and C6 in M and L manure application levels.

Figure 3 shows the changes in the total nitrogen absorption (TNA) of the herbage part in 1995 (TNA_{1995}) and the ratio of TNA in 1995 to that in 1994 ($TNA_{1995/1994}$), as affected by the cutting frequency and manure application level in the previous year. The TNA_{1995} increased with the increase in manure application and with the decrease in cutting frequency. The $TNA_{1995/1994}$ was correlated positively with TNA_{1995} ($r=0.642$, $P<0.10$), and TNA_{1995} was absolutely higher at more than four times than that in 1994 at the cutting frequency of C1 in every manure level, even though manure was not supplied in 1995. The increase in TN concentration in 1995, compared with that in 1994, lead to more than doubled increase in TNA_{1995} than TNA in 1994, suggesting that mineralization of applied manure was much promoted in the following year of manure application. The variation of TNA among cutting and manure-applied treatments enlarged from that of DMY in 1995.

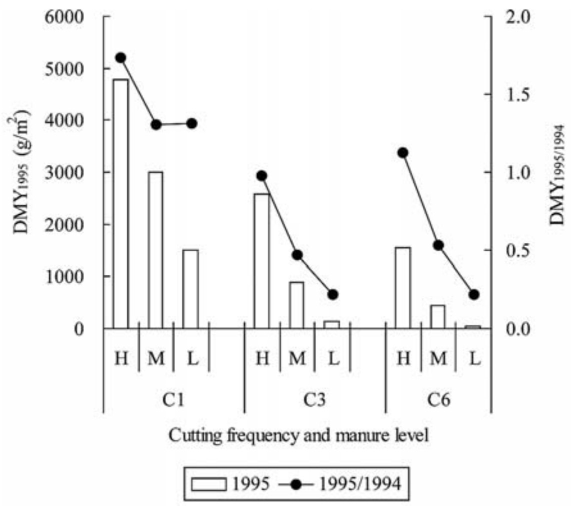

Fig. 2. Dry matter yield (DMY) of herbage in 1995 (DMY_{1995}) and ratio of DMY in 1995 to that in 1994 ($DMY_{1995/1994}$) as affected by cutting frequency and manure application level in 1994.
Cutting frequency : C1, C3, C6 (one-, three- and six-times cutting, respectively).
Manure application level : H, M, L (high, medium and low level, respectively).

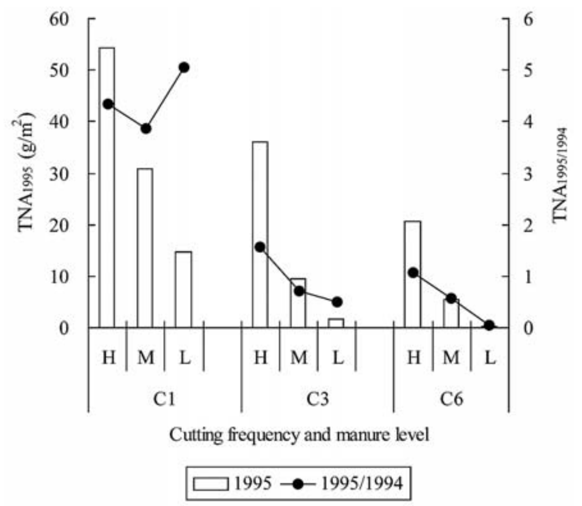

Fig. 3. Total nitrogen absorption (TNA) of herbage in 1995 (TNA_{1995}) and ratio of TNA in 1995 to that in 1994 ($TNA_{1995/1994}$) as affected by cutting frequency and manure application level in 1994.
Cutting frequency : C1, C3, C6 (one-, three- and six-times cutting, respectively).
Manure application level : H, M, L (high, medium and low level, respectively).

Figure 4 shows the changes in the total *in vitro* digestible dry matter yield (TIVDDMY) of herbage part in 1995 ($TIVDDMY_{1995}$) and the ratio of TIVDDMY in 1995 to that in 1994 ($TIVDDMY_{1995/1994}$), as affected by the cutting fre-quency and manure application level in the pre-vious year. The $TIVDDMY_{1995}$ increased with the increase in manure application and with the de-crease in cutting frequency. The $TIVDDMY_{1995/1994}$ was corre-lated positively with $TIVDDMY_{1995}$ ($r=0.799$, $P<0.01$). $TIVDDMY_{1995}$ was absolutely higher at more than two times than that in 1994 at the cutting frequency of C1 in every manure level, due to the higher herbage DMY combined with higher IVDMD at the twice-cutting in 1995, as in the same tendency of the previous study (Mohammad *et al.* 1988 ; Hsu *et al.* 1989 ; Woodard and Prine 1991).

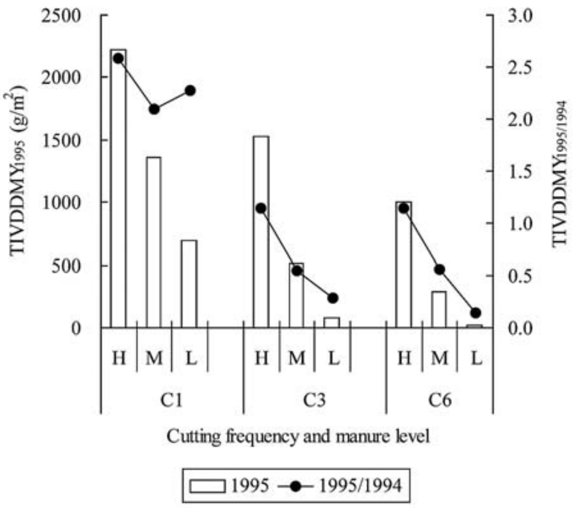

Fig. 4. Total *in vitro* digestible dry matter yield (TIVDDMY) in 1995 ($TIVDDMY_{1995}$) and ra-tio of TIVDDMY in 1995 to that in 1994 ($TIVDDMY_{1995/1994}$) as affected by cutting fre-quency and manure application level in 1994.
Cutting frequency : C1, C3, C6 (one-, three- and six-times cutting, respectively).
Manure application level : H, M, L (high, medium and low level, respectively).

Input, output and residual total nitrogen

Figure 5 shows the changes in input and output of total nitrogen (TN) for 3 year's harvest, as affected by the cutting frequency and manure application level in 1993 and 1994. Output of TN increased with the increase in manure application, while the residual TN in 1995 decreased with the decrease in manure application. Thus, nitrogen use efficiency of applied manure increased with the decrease in manure application and cutting fre-quency, and ranged from 24 % at C6 in H-level through to 40 % at Cl in M-level, if the data at the low manure application would be neglected. In L-level, residual TN at every cutting frequency showed negative, suggesting that napiergrass absorbed nitrogen in the original soil. In the present study, napiergrass can absorb the TN content of applied manure up to 40 % in the applied and following years at both H- and M-levels, and the unabsorbed mineralized elements had a risk to leak from the system through runoff, penetration into ground water (Idota *et al.* 2005) and denitrification.

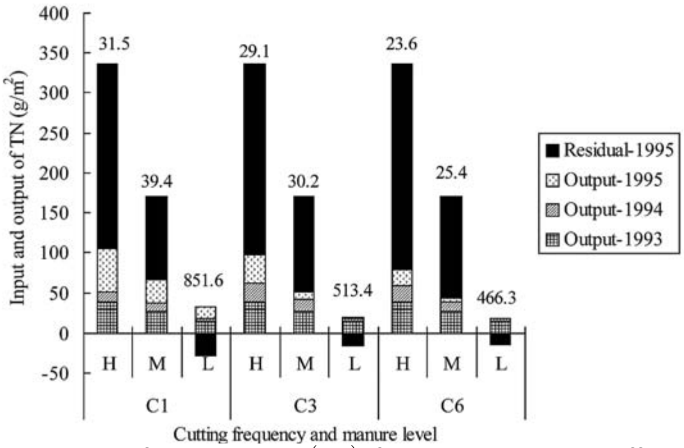

Fig. 5. Input and output of total nitrogen (TN) for 3 years' harvest as affected by cutting frequency and manure application level in 1994.
Cutting frequency : C1, C3, C6 (one-, three- and six-times cutting, respectively).
Manure application level : H, M, L (high, medium and low level, respectively).
Figures on the column denote nitrogen use efficiency (%).

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Conclusions

In this study, cutting frequency at the previous year showed the prominent effect on the growth of napiergrass in the following year. Severe cutting frequency at 6 times per year reduced the herbage dry matter yield at less than 50 % in the following year. However, high manure application mitigated the negative effect of severe cutting frequency on herbage dry matter yield. In all aspects of dry matter, nitrogen absorption and digestible dry matter, higher yield in the following year after manure application suggested the promoting mineral-ization of applied manure in the following year, compared with the applied year.

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* : In Japanese with the English summary.
** : In Japanese (Translated title by the authors).

ネピアグラスの乾物収量と***in vitro***乾物消化率に対する堆肥施用の後作用

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要 約

ネピアグラス（品種Wruk wona）の乾物収量と*in vitro*乾物消化率（IVDMD）に対する前年度２ヵ年の堆肥施用と刈取り頻度の後作用を，成長形質（乾物重，葉面積），窒素吸収量および*in vitro*可消化乾物収量の面から，３年目に無施肥の２回刈り条件で検討した。

収穫部の乾物収量，全窒素吸収量および*in vitro*可消化乾物収量は堆肥施用量が増すほど増加し，刈取り頻度が増すほど低下した。３ヵ年の実験期間における施用した堆肥中の窒素利用効率は，堆肥施用量が増すほど，あるいは刈取り頻度が増すほど低下した。

キーワード：*in vitro*乾物消化率，乾物収量，後作用，堆肥，ネピアグラス