Dry Matter Productivity of the Dwarf and Normal Elephantgrasses as Affected by the Planting Density and Cutting Frequency

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ABSTRAK

MUKHTAR, M. 2006. Produktivitas bahan kering rumput Gajah dwarf dan normal sebagai dampak pengaruh kepadatan tanaman dan frekuensi pemotongan. *JITV* 11(3): 198-205.

Pengaruh kepadatan tanaman dan frekuensi pemotongan terhadap produktivitas bahan kering rumput Gajah yaitu dua varitas dwarf (pembungaan-cepat, DE dan pembungaan-lambat, DL) dan dua varietas normal (Wruk wona, Wr dan Merkeron, Me) akan dibandingkan dalam dua tahun pertumbuhan di bagian selatan Kyushu, Jepang. Pengujian kepadatan tanaman dibagi tiga yaitu kepadatan tinggi dengan jarak 25 cm × 25 cm (16 tanaman/m^2), medium dengan jarak 50 cm × 25 cm (8 tanaman/m^2), dan rendah dengan jarak 50 cm × 50 cm (4 tanaman/m^2) untuk varietas Wr, DE dan DL, dan khusus varietas Me hanya pada jarak tanam medium. Frekuensi pemotongan dibagi dua yaitu tiga kali atau sekitar 60-hari interval pemotongan pada tahun 2002 dan pada tahun 2003 sebanyak dua kali atau sekitar 90-hari interval pemotongan. Kepadatan tanaman, produksi jumlah tunas, luas area daun dan persentase produksi daun menunjukkan hasil yang lebih besar pada varietas dwarf dibandingkan dengan varietas normal, akan tetapi produksi tinggi tanaman dan total produksi bahan kering pada semua kepadatan tanaman selama dua tahun rendah. Semakin tinggi kepadatan tanaman, produksi bahan kering tahunan meningkat pula. Produksi bobot kering tanaman per tahun (HDMY) lebih tinggi pada tahun 2003 (pemotongan dua kali) dibandingkan produksi bahan kering tahunan pada tahun 2002 (pemotongan tiga kali), serta perbedaan produksi bahan kering tahunan antara varietas dwarf dan normal menurun pada penanaman dengan kepadatan tinggi dan pemotongan dua kali. Walaupun produktivitas bahan kering lebih tinggi pada varietas normal dibanding varietas dwarf pada setiap kepadatan tanaman dan frekuensi pemotongan, DL cenderung memperlihatkan produktivitas yang stabil dengan persentase daun yang tinggi terhadap kepadatan tanaman dan frekuensi pemotongan.

Kata Kunci: Frekuensi Pemotongan, Produktivitas Bahan Kering, Varietas Dwarf, Varietas Normal dan Kepadatan Tanaman

ABSTRACT

MUKHTAR, M. 2006. Dry matter productivity of the dwarf and normal elephantgrasses as affected by the planting density and cutting frequency. *JITV* 11(3): 198-205.

The effects of planting density and cutting frequency on dry matter productivity were compared in two years following establishment among dwarf varieties (early-heading, DE and late-heading, DL) and normal varieties, Wruk wona (Wr) and Merkeron (Me), in the southern part of Kyushu, Japan. The planting densities examined for Wr, DE and DL were high (16 plants/m^2, 25 cm × 25 cm of spacing), medium (8 plants/m^2, 50 × 25 cm), and low (4 plants/m^2, 50 cm × 50 cm), while for Me was only medium. The cutting frequency was three times with 60-day intervals in 2002 and two times with 90-day intervals in 2003. Irrespective of the planting densities, dwarf varieties were higher in tiller number, leaf area index and percentage of leaf blade (PLB) than those of normal varieties, but lower in plant height and total dry matter weight at all planting densities in both years. With the increase in planting density, annual herbage dry matter yield (HDMY) increased. The annual HDMY was higher in 2002 (cut twice) than that in 2003 (cut three times), and the difference in annual HDMY between the dwarf and normal varieties decreased by planting at high density and cut twice. Even though, the dry matter productivity was higher in the normal varieties than in the dwarf varieties at any planting density and cutting frequency, DL tended to show a stable productivity with high PLB irrespective of planting density and cutting frequency.

Key Words: Cutting Frequency, Dry Matter Productivity, Dwarf Elephantgrass, Normal Elephantgrass and Planting Density

INTRODUCTION

Many cultivars of dwarf Elephantgrass (*Pennisetum purpureum* Schumach) have recently been grown and examined for their growth characteristics in the tropical and sub-tropical regions in the world (CUOMO *et al*., 1996; HANNA and MONSON, 1988; KIPNIS and BNEI-MOSHE, 1988). Dwarf Elephantgrass facilitates hand-harvesting by farmers and is assessed to be more suitable for grazing than normal variety (RUSLAND *et al*., 1993; WILLIAMS and HANNA, 1995). Dwarf varieties were different from normal varieties in tiller number, mean tiller weight and percentage of leaf blade in a preliminary study using the plants (ISHII *et al*., 1998).

In order to recommend cultivation of dwarf elephantgrasses to grass producing farmers in Miyazaki, Southern part of Japan, it is necessary to examine growth characteristics of dwarf elephantgrass as affected by planting density and cutting frequency in the year after establishment as well as in the established year. In normal elephantgrass, growth and yielding characteristics such as dry matter yield, tiller density and leaf area index (LAI) were higher in a high-density plot (8.2 plants/m^2) than in low-density plot (4.0 plants/m^2) by 20 – 30% throughout the growing period (ITO *et al*., 1989). It is natural that dry matter yield increased with the increase in planting density. However, since elephantgrass is propagated vegetatively with stem cuttings or rooted tillers (KIPNIS and BNEI-MOSHE, 1988), establishment efficiency decreases and its cost increases with the increasing planting density. Thus, it is necessary to investigate the effect of planting density on DMY and related growth characters. Cutting frequency is another important management practice for maintaining forage quality and guaranteeing the continuous regrowth of elephantgrass. It is known that the annual DMY is higher under less frequent cutting than under frequent cutting, because a larger amount of dry matter accumulates in the stem part under infrequent cutting. However, low leaf/stem ratio is associated with low forage quality such as low digestibility and low crude protein content (ISHII *et al*., 1996b; SUNUSI *et al*., 1997). SOLLENBERG and JONES (1989) shows that a dwarf Elephantgrass of Mott produced excellent forage yield under the continuous grazing management and achieved the live weight gain of nearly 1 kg/day for the beef cattle in Florida, USA, which was superior to the ordinary Pensacola *bahiagrass*. Thus, the relationship between DMY and ratio of leaf to stem should be examined in the dwarf and normal elephantgrasses as affected by the cutting frequency. The annual DMY of Elephantgrass in the year of establishment differs from that in the following year. The DMY in the established year is used to increase the regrowth in the following year (ITO *et al*., 1988). The growth rate in the following year (regrowing from the stubble) is higher than that in the transplanted year, if the overwintering percentage is sufficiently high. In this study, only the plants in the year after establishment were used, since the productivity of elephantgrass in this region of Southern Kyushu island is closely correlated with the overwintering ability (ISHII *et al*., 1996a), as in some tropical grasses (CAI *et al*., 1999).

The objective of this study was to examine the effect of planting density and cutting frequency on dry matter productivity in the years after establishment in the dwarf and normal elephantgrasses in the Southern part of Kyushu, Japan.

MATERIALS AND METHODS

Plant materials

The research was carried out at the Experimental field Station, Miyazaki University, Japan from May 2002 to April 2003. The examined varieties were two normal varieties, Wruk wona (Wr) and Merkeron (Me), and two dwarf varieties introduced from Thailand. Since the two dwarf varieties were definitely different in the heading date, early-heading variety was termed DE and late-heading variety DL. Normal variety of Me was a leading variety in Miyazaki and used as a control variety.

As a basal dressing was fermented cattle manure at dose 600 g/m^2 and slaked lime at 400 g/m^2 applied in May. As additional dressing, 10 g of N, P_2O_5 and K_2O/m^2 of chemical compound fertilizer were applied three times in both 2002 and 2003.

In May 2003, soil at the top 5 cm layer were analyzed. The pH was measured with a pH meter (HM-7E, TOA Electronic Co. Ltd.), electric conductivity (EC) at soil : water = 1 : 5 (v/v) with an EC meter (CM-40S, TDA Co. Ltd.) and chemical contents with a Dr. Soil kit (Fujihira Kougyou Co. Ltd.). The pH (H_2O) was 7.4, pH (KCl at pH 7) was 6.7, EC was 64.1 μS/cm^2. NO_3-N, NH_4-N and available P_2O_5 contents were estimated to be 1, 5, and 15.8 mg in 100 g soil, respectively.

Experimental design

The experimental plots were arranged in a blocked design of Latin square method at three replications for each planting density. Each variety was planted at a high density (16 plants/m^2, 25 cm × 25 cm of spacing), medium density (8 plants/m^2, 50 cm × 25 cm), and low density (4 plants/m^2, 50 cm × 50 cm) except Me, which was planted only at the medium density. Plot sizes were 5 m^2 (2 m × 2.5 m), 7.5 m^2 (2.5 m × 3 m), and 12 m^2 (3 m × 4 m) for the high, medium and low density, respectively. The plants were cut three times at about 60-day intervals, on July 5, September 11 and November 23 in 2002, and two times at about 90-day intervals on July 31 and November 3 in 2003. The cutting height was 10 cm above the ground.

Sampling methods for the growing period

A single plant per replication (three replications for each density) was sampled and divided into herbage part, stubble part and underground part. The herbage part was cut at 10 cm above the ground surface, and measured for plant height (PLH), tiller number (TN), leaf area (LA) and dry matter weight (DMW) of leaf blade (LB), stem with leaf sheath (ST) and dead part (D). The stubble part was cut at the ground surface, and measured for DMWs of LB, ST and D. The underground part was measured for DMW of underground stem (UG) excluding roots. Fresh and dry matter yields were measured for five plants in each replication and three replications per variety.

Data analysis

The data were analyzed statistically by the analysis of variance and the difference in the mean value was calculated by the LSD method at 5% level.

RESULTS

Climatic conditions

Figure 1 shows mean air temperature, solar radiation and precipitation during the growing period in 2002 and 2003 from the data of Miyazaki Meteorological Observatory. Mean air temperature and solar radiation were generally higher in 2003 than in 2002, especially in July and August. Since the average precipitations in a normal year are 288 mm in July and 294 mm in August, the amount of rainfall was much larger, and mean air temperature and solar radiation were lower in July and August in 2002 than those in a normal year. In 2003, mean air temperature and solar radiation from late June to middle July were higher than in a normal year.

Growth characters and dry matter weight

The changes in growth characters and dry matter weight with time were compared among normal (Wr and Me) and dwarf (DE and DL) varieties cut three times in 2002 (Figure 2) and two times in 2003 (Figure 3).

Plant height was generally larger in normal varieties, Wr and Me, than in dwarf varieties, DE and DL in both years, except in November 2003 when DE and Wr had a similar PLH. Both the normal and dwarf varieties reached a maximum PLH in September and November in 2002 and 2003. Since the regrowth period from the first to the second cutting was longer in 2003 than in 2002, PLH in November 2003 reached almost 3 m in all varieties except for DL. This indicated that normal varieties and DE elongated stems after reproductive organ initiated. The PLH in Wr tended to be higher in the low-density plots than in higher density plot. On the contrary, PLH in DL was less than 2 m, irrespective of planting density, which matched with the previous study for the uncut vegetative height in dwarf varieties (SOLLENBERG and JONES, 1989; BURTON, 1989).

In all varieties, total DM at the second cutting was larger than that at the first cutting in both years, but that at the third cutting in 2002 was lighter. Total DM among varieties tended to vary with the cutting times in both years. It tended to be larger in normal varieties than in dwarf ones at the first cutting in both years, but at the second cutting dwarf varieties produced larger total DM than normal varieties in 2002, and the difference in total DM among varieties was small at the last cutting in both years.

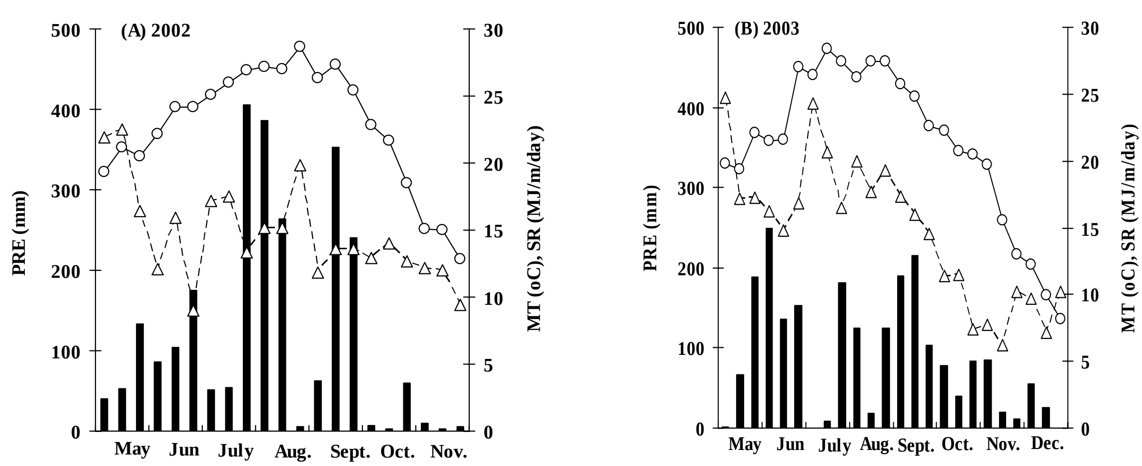

Figure. 1. The mean air temperature (MT, O), solar radiation (SR, Δ) and precipitation (PRE, ■) during the experimental period

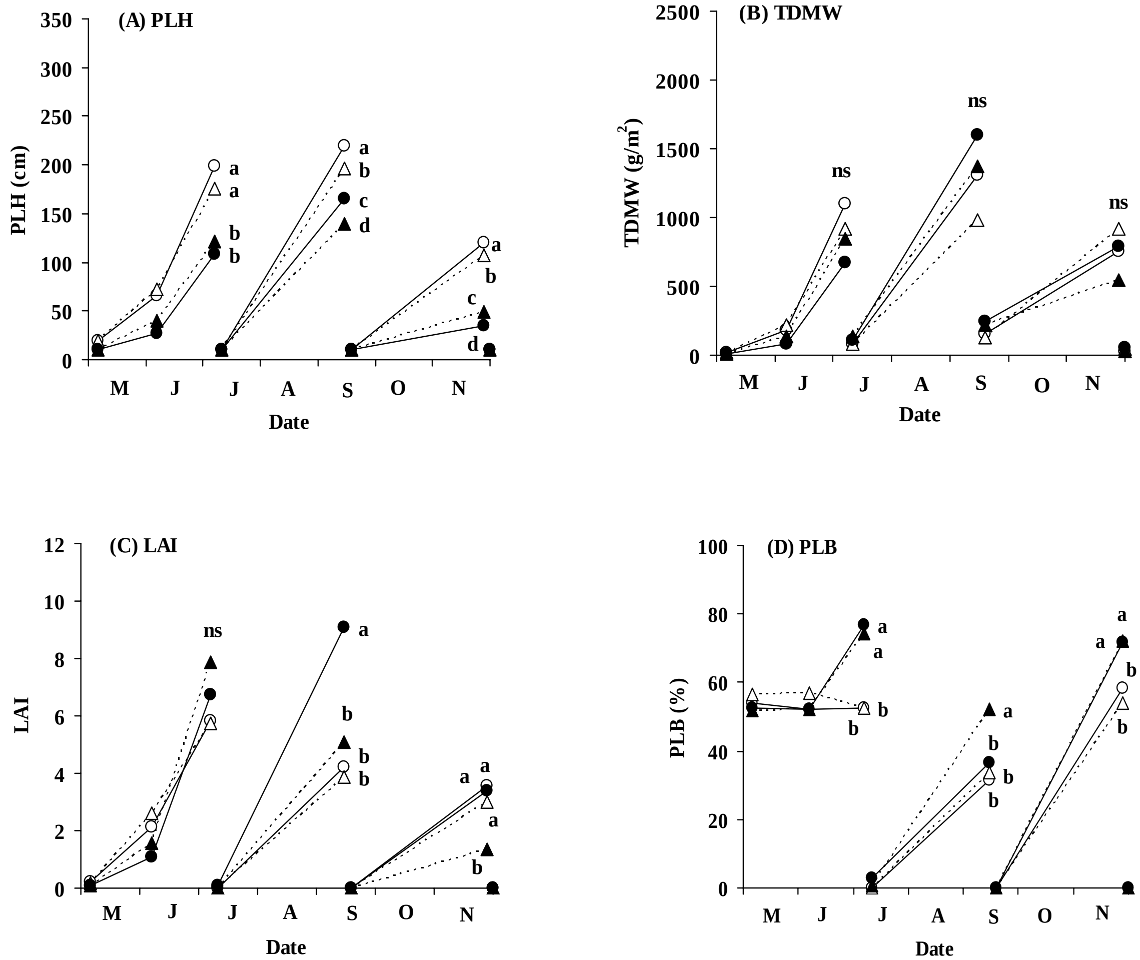

Figure. 2. Plant height (PLH, A), total dry matter weight (TDMW, B), leaf area index (LAI, C) and dry weight percentage of leaf blade (PLB, D) in 2002

Wruk wona (Wr, ○), Merkeron (Me, Δ), Dwarf-early (DE, ●) and Dwarf-late (DL, ▲) , Arrows indicate the dates of cutting. Figures with different letters denote significant difference among varieties at 5% level. ns: not significant

Leaf area index (LAI) was generally larger in the dwarf varieties than in normal ones, except at the third cutting in 2002 and at the first cutting in 2003. In 2002, LAI tended to decrease by repeated cuttings except in DE, while LAI at the first cutting was similar to that at the second cutting in 2003. The LAI was larger at both cuttings in 2003 than at all cuttings in 2002 due to longer regrowth period.

The dry weight percentage of leaf blade (PLB) was also larger in the dwarf varieties than in the normal ones in both years, except for DE at the second cutting in both years. The PLB at the second cutting was lower than that at the first cutting in all varieties in both years, but that at the third cutting in 2002 was similar to that at the first cutting.

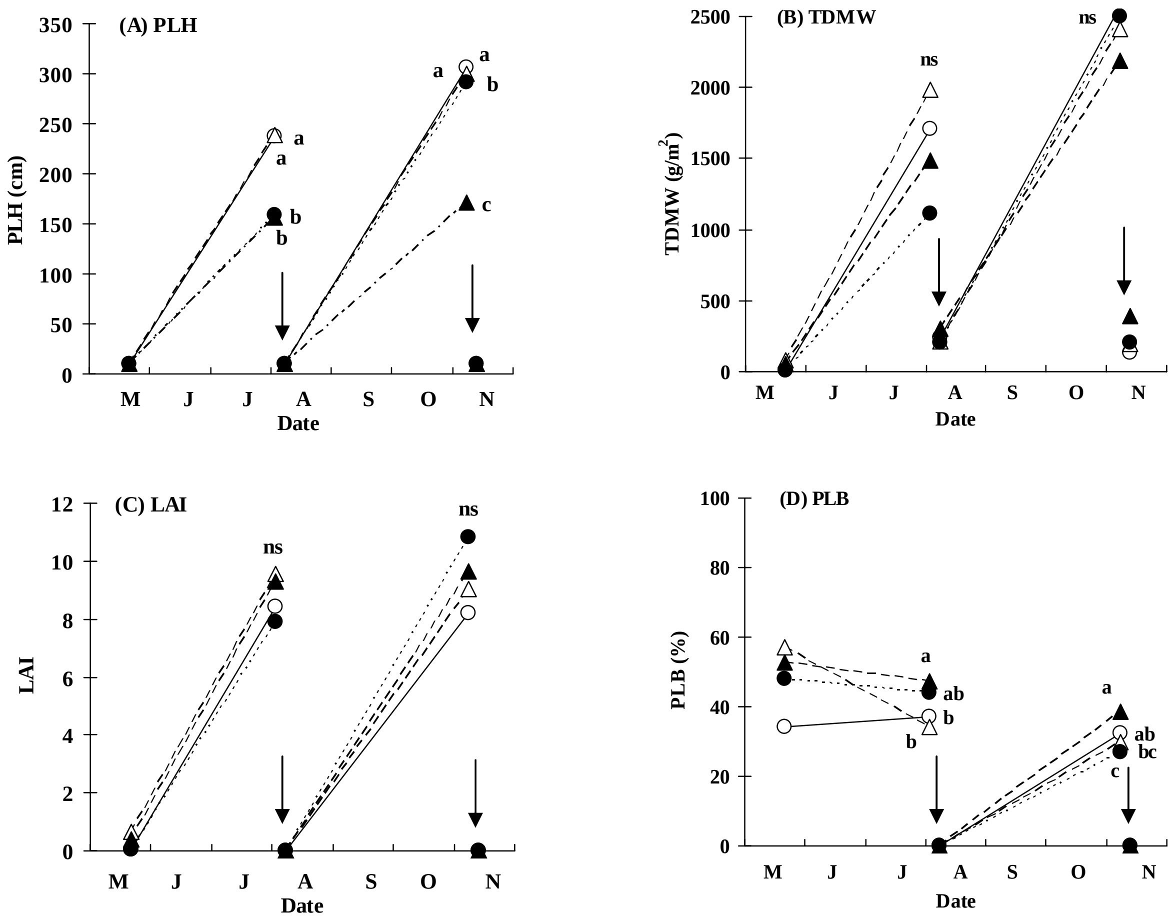

Figure. 3. Plant height (PLH, A), total dry matter weight (TDMW, B), leaf area index (LAI, C) and dry weight percentage of leaf blade (PLB, D in 2003.

Wruk wona (Wr, ○), Merkeron (Me, Δ), Dwarf-early (DE, ●) and Dwarf-late (DL, ▲). Arrows indicate the dates of cutting. Figures with different letters denote significant difference among varieties at the same cutting date at 5% level. ns: not significant.

Herbage yield

The annual herbage dry matter yield at each cutting, and PLB in the herbage part at each cutting in 2002 and 2003 are shown in Fig. 4.

The yield was higher in 2003 (cut twice) than in 2002 (cut three times) in all varieties. HDMYs were the highest in the second cutting, followed by the first cutting in both years and were the lowest in the third cutting in 2002 in all varieties. The present study indicated that the increase in cutting frequency (from two to three times) reduced the annual herbage dry matter yield. The annual herbage dry matter yield increased as planting density increased in all varieties in both years. The annual herbage dry matter yield was the highest in Wr, followed by Me, DE and DL in both years, while the difference in annual herbage dry matter yield among varieties was the least at a high density under twice cutting in 2003.

PLB was slightly affected by planting density, except for DE at the first cutting in both years when PLB tended to increase with the increase in planting density. It was higher in dwarf varieties than in normal varieties at all cuttings in 2002 and tended to be higher in both cuttings in 2003, except for DE at the second cutting.

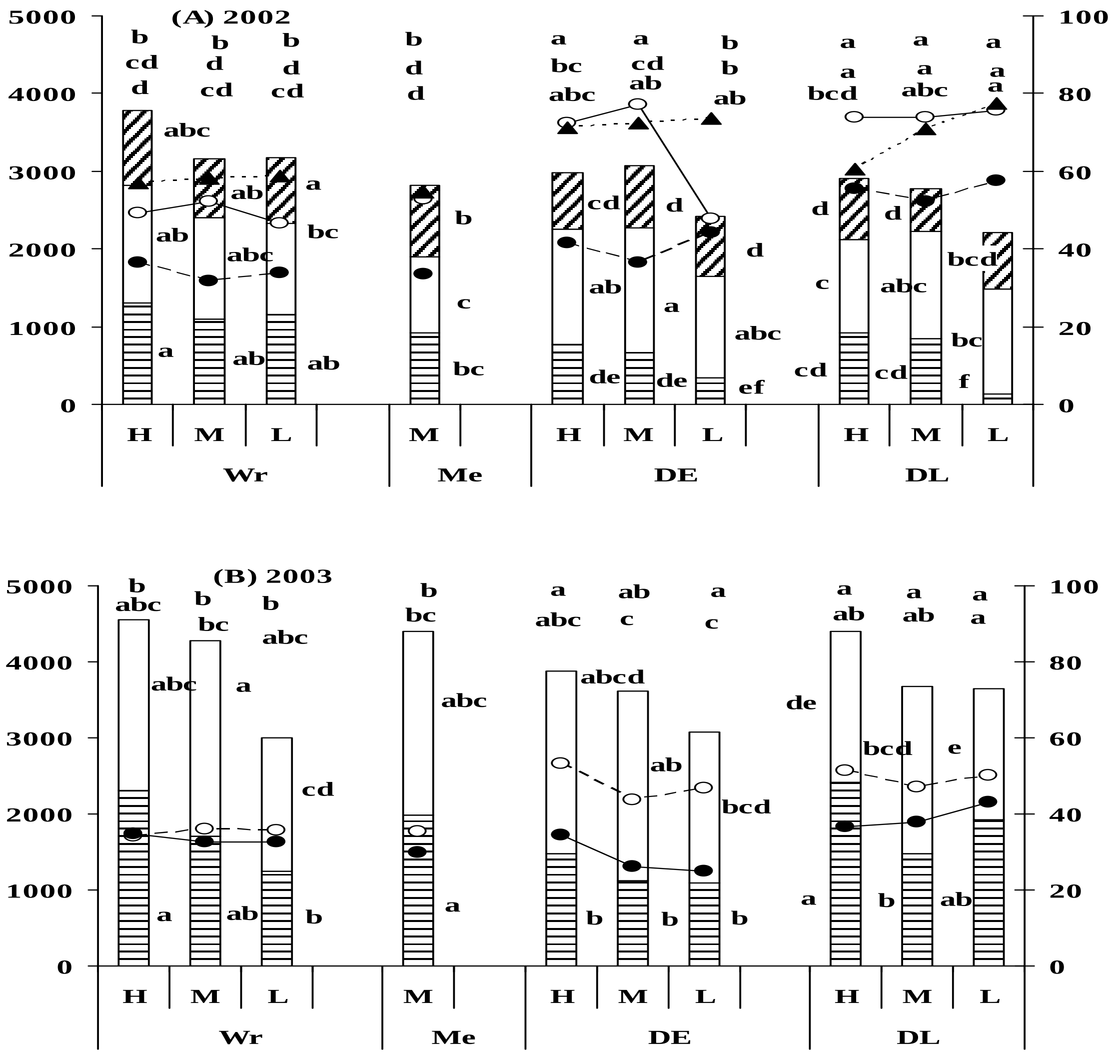

Figure. 4. Annual total of dry matter yield and dry matter weight of leaf blade (PLB) in 2002 (A) and 2003 (B). Bar chart HDMY): First-cut (▤), second-cut (☐), and third-cut (☐).

Dot chart (PLB) : First((1st)-cut (○), second (2nd)-cut (●), and third (3rd)-cut (▲).
Density : H (16 plants/m²), M (8 plants/m²), and L (4 plants/m²).
Figures with different letters on the bar and besides the bar denote significant differences in PLB and HDMY, respectively, among different densities and varieties at 5% level

DISCUSSION

Herbage dry matter yield increased with the increase in planting density from 4 to 16 plants/m^2. It was reported in elephantgrass that HDMY increased as planting density increased from 1.6 to 4 plants/m^2 by MIYAGI (1980), and from 4 to 8.2 plants/m^2 by ITO *et al*. (1989). Tiller number increased as planting density increased as reported by MIYAGI (1980) and ITO *et al.* (1989), while MTW tended to decrease as planting density increased in all cuttings, except for the first cutting in 2003 (when MTW was not influenced by planting density).

In 2003, HDMY showed the saturated response to planting density at medium to high densities in Wr and DE, while it tended to be saturated only at high density in DL. The difference in the response of HMDY to planting density between DE and DL in 2003 may be derived from the difference in leaf angel. Since DL had a more vertical leaves than DE in our observation, it is suggested that DL is more fitted to higher LAI for increasing the efficiency of solar radiation interception as observed in forage crops such as maize (GARDNER *et al*., 1985) and in normal elephantgrass (ITO *et al*., 1989).

HDMY decreased as cutting frequency increased from twice (2002) to three times (2003), although MTW also decreased severely as cutting frequency increased. Since the effect of cutting frequency was estimated by comparing the results obtained in the different years (2002 and 2003) in this study, it is necessary to consider the climatic conditions in the two years. Plants hardly suffered from the drought stress in both summers, though there was less precipitation in 2003. In normal elephantgrass, HDMY decreases with the increase in cutting frequency (MIYAGI, 1985; WOODARD and PRINE, 1991; SUNUSI *et al*., 1997). WOODARD and PRINE (1991) reported that the dwarf variety of Mott was less sensitive to the increased cutting frequency than normal varieties, although the two dwarf varieties in the present study were sensitive to cutting frequeny. This characteristic, insensitive to the cutting frequency may be due to the earlier recovery of ground cover by the leafage after harvest (GARDNER *et al*., 1985) because of larger TN in dwarf varieties than in normal varieties. It is necessary to compare the change in relative light intensity at the ground surface after cutting among varieties to support the above idea.

The dry matter productivity in normal elephantgrass is sensitive to the decrease in air temperature (MIYAGI 1980; ISHII *et al*., 1996b). From the experiment in 2002, DL is assessed to be more sensitive to the decrease in air temperature than normal ones. A great decline of HDMY at the third cutting in DL may be attributed to the non-heading characteristics of DL. Since elongated stem functions as a storage organ, DL may lack in the sink capacity under a low air temperature at the third cutting in 2002.

LAI positively correlated with HDMY and negatively with PLB in both years. These correlations suggest that as planting density increases, LAI increases with the concomitant increase in PLB, and that as cutting frequency increases, LAI decreases with the concomitant decrease in HDMY and increase in PLB. These correlations should be considered in aspect to herbage quality (CUOMO *et al*., 1996; ISHII *et al*., 1996b; SUNUSI *et al.,* 1997).

CONCLUSIONS

Dwarf variety of dwarf-late shows a stable productivity at any planting density irrespective of cutting frequency. This characteristic may be derived from high capacity of tiller emergence at the cutting and high dry weight percentage of leaf blade in DL, compared with the normal varieties.

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