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Adaptability and Extension Activity of Dwarf Napiergrass in Southern Kyushu and Elsewhere since Its Introduction to Japan 15 Years Ago

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Adaptability and extension activity of dwarf napiergrass in southern Kyushu and elsewhere since its introduction to Japan 15 years ago

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Abstract. Southern Kyushu is well suited to the cultivation of tropical grasses due to its warm climate, history of herbage production, and extensive areas of abandoned arable land. In 1996, a C_4-tropical dwarf variety of a late-heading (DL) napiergrass (*Pennisetum purpureum* Schumach) was introduced from the USA into southern Kyushu via Thailand. Since 2004, DL napiergrass has been evaluated for its production potential, overwintering ability, and suitability for grazing. In Miyazaki, napiergrass exhibits superior sustainability, persisting for more than 5 years without annual renovation. The species shows excellent overwintering ability in coastal areas and is resilient to pathogens and insects. Evaluation at several sites in southern Kyushu revealed that DL napiergrass required minimum winter temperatures to be above –6.2°C to persist over winter. Cultivation of this grass has been successfully extended to more than 10 sites, including isolated islands around Kyushu and at several of these sites livestock farms are now using DL napiergrass. Temperate Italian ryegrass (*Lolium multiflorum* Lam.) can be successfully established in the inter-row to increase biomass in spring and is well utilized by grazing beef cattle. However, the transplantation of DL napiergrass requires the use of nursery plants for vegetative propagation, and this has been efficiently developed using multi-celled tray beds. DL napiergrass cannot survive the winters of central and northern Japan, however as the species produces 5–18 T DM/ha/yr of highly palatable and good quality herbage, there is potential to increase its use as an annual pasture in these areas.

Keywords: Dwarf napiergrass, adaptability, extension, cut-and-carry, grazing, vegetative propagation.

Introduction

A dwarf variety of late-heading type (dwarf-late, DL) napiergrass (*Pennisetum purpureum* Schumach) was developed in Florida, USA (Sollenberger *et al*. 1988) and first introduced to Miyazaki, Japan via Thailand in 1996 (Mukhtar *et al.* 2003). The cultivation of this species is gradually increasing as herbage in cooperation with University of Miyazaki and regional communities in several prefectures of Kyushu. Compared with normal type, DL napiergrass is lower in DM productivity, while it has a higher percentage of leaves and lower lignin content (Rengsirikul *et al*. 2011). The objectives of this study are to extend the cultivation of DL napiergrass by demonstrating optimal sites and management practices for use as a perennial, intercropping with Italian ryegrass (*Lolium multiflorum* Lam.) and development of vegetative propagation.

Methods

Production potential, overwintering ability, and suitability for grazing (Experiment 1)

Four paddocks of DL napiergrass pasture (500 m^2, 20 m × 25 m/paddock) were established by rooted tillers on 6 May 2002 and another two paddocks the same size on 5 May 2004 in Miyazaki (Ishii *et al.* 2005). The DL pasture was rotationally grazed for a week by 2-3 beef cows (Japanese-Black, JB) with a 3-week rest period for 6 cycles in 2003, and by 3 JB beef cows with a 5-week rest period for 4 cycles in 2004−2005, and by 1 JB beef and 2 dairy breeding cows with a 5-week rest period for 3 cycles in 2006. The liveweight was measured at 1100 h when the cows moved paddocks. No concentrate or roughage was fed during this rotational grazing. Herbage mass (HM) was determined by cutting plants 10 cm above the ground before and after grazing. Italian ryegrass was oversown into inter-row space in early November after grazing the DL napiergrass. The Italian ryegrass pasture was grazed from early March to late May in 2004−2007.

Suitability of DL napiergrass for regional sites in Kyushu (Experiment 2)

The first trial was initiated in May 2002. After ploughing, DL napiergrass pastures were established by transplanting rooted tillers at 2 plants/m^2 (50 cm × 100 cm grid), over an area of 100−200 m^2 at 5 sites (Miyazaki, Minamata, Itsuwa, Koshi and Shimabara of Kyushu island), which except for

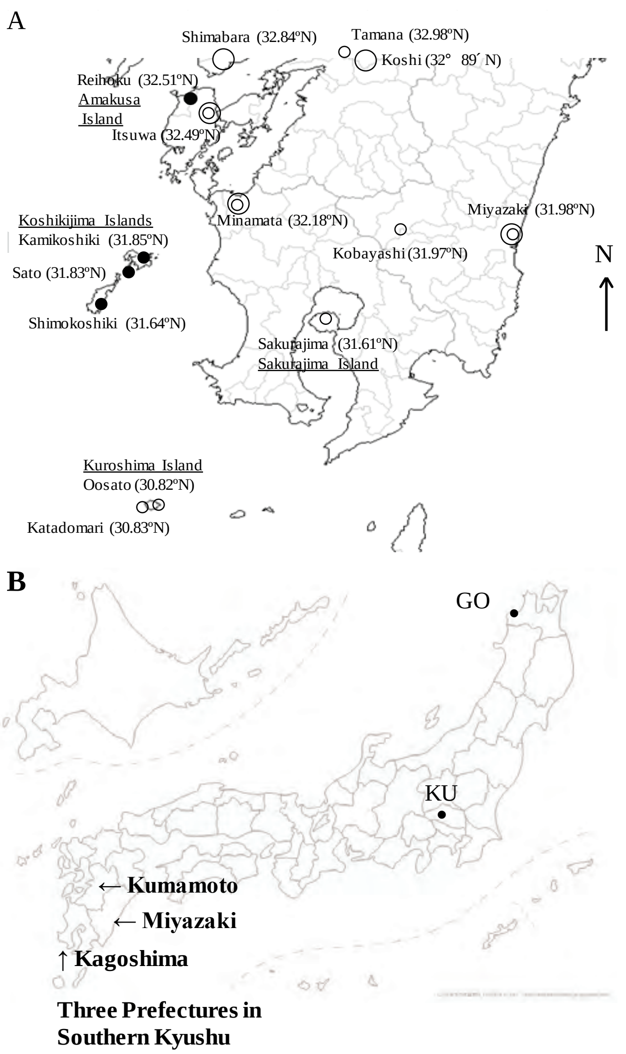

Figure 1. Experimental sites with latitudes in 2002-2006 (○) and 2007-2009 (●) in southern Kyushu (A), and sites in northern (GO) and central (KU) Japan (B). Map modified from Utamy *et al.* (2012).

Koshi and Shimabara, are located in coastal areas (Ishii *et al*. 2008). Determination for HM was as per Experiment 1 and assessed 89−98 days after planting each year. Overwintering ability was assessed in June of the following year. Climate data was obtained from a meteorological observatory neighbouring the site. This trial was repeated in May 2007 and 2008 for coastal and remote island areas. From Miyazaki, Kumamoto and Kagoshima Prefectures in southern Kyushu, 10 and 8 sites were selected in 2007 and 2008, respectively, as a site to be promised for perennial use and novel cultivation of DL napiergrass (Fig. 1A). At each site, surface soils (0−10 cm) were analysed for pH (H_2O), electric conductivity (EC), total nitrogen (TN) and total carbon (TC). Prior to defoliation the plant height, tiller number, DM of each plant fraction was measured and herbage samples analysed for *in vitro* DM digestibility (IVDMD) and crude protein (CP).

Improvement of nursery production efficiency by vegetative nursery propagation (Experiment 3)

The genotypes of Napiergrass used were: normal type, Wruk wona (WK) and DL in autumn 2010, and DL, early heading dwarf-type (DE), WK, normal type and Merkeron (ME) in autumn 2011. Genotypes of DL, and DE, WK and ME were used for spring nursery production in 2010 and 2011, respectively. Standard nursery production methods by dividing overwintered stubbles into rooted tillers were only applied to DL in the spring of 2011.

Suitability of DL napiergrass for northern and central parts of Japan (Experiment 4)

Sites for the northern and central regions of Japan were Goshogawara in Aomori Prefecture (abbreviated as GO, 40.90ºN, 140.46ºE) and Kumagaya in Saitama Prefecture (KU, 36.11ºN, 139.35ºE), respectively (Fig. 1B). After ploughing, DL napiergrass was planted at 1 plant/m^2 in late May 2012 in GO and at 2 plants/m^2 in mid-May 2008 in KU and supplied with 14, 25 and 20 g N, P_2O_5 and K_2O, each/m^2/year in GO and KU, respectively. Determination for HM was the same as in Exp. 1 and assessed 18 and 16 weeks after planting in GO and KU, respectively. Feed quality in terms of CP, NDF, ADF and TDN contents was determined by near-infrared spectrophotometry.

Results and discussion

Production potential, overwintering ability, and suitability for grazing (Experiment 1)

DL napiergrass pastures were grazed for 151, 120, 126 and 126 days in 2003, 2004, 2005 and 2006, respectively. Daily liveweight gains (LWG) were 0.44, 0.43, 0.56 and 0.23 kg/head/day, respectively. Pasture utilization was very high as herbage consumption (HC) was almost the same as HM before grazing (Fig. 2). A positive correlation was obtained (r = 0.804, $P < 0.01$) between HM and HC across cycles and years in 2005−2006. It is essential to maintain satisfactory HM of DL napiergrass at the first cycle in each year to enhance HC across the whole season. The oversown Italian ryegrass was grazed for 10-14 days in spring.

Suitability of DL napiergrass for regional sites in Kyushu (Experiment 2)

The first defoliation was conducted 89-98 days after the establishment, when the DL napiergrass was 111−132 cm tall. At the first defoliation, plants varied considerably in herbage yield (DM) 226−717 g DM/m^2 and percentage of leaf blade (PLB) 61−87%, based on early prompt pasture management of weeding and fertilization (Utamy *et al*. 2012). Even though sufficient manure was applied, weed

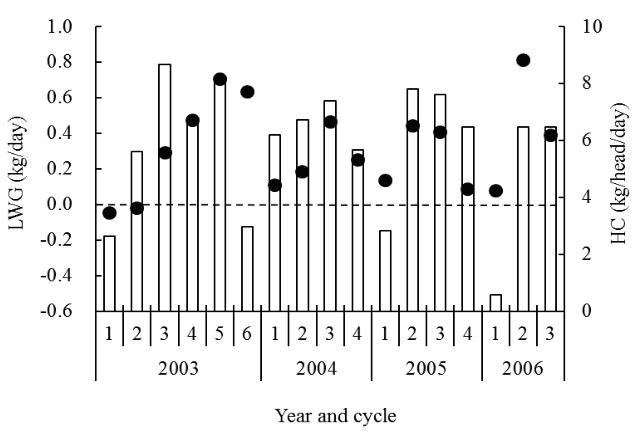

Figure 2. Changes in liveweight gain (LWG, dot) and herbage consumption (HC, bar) by breeding beef cows in each cycle.

Table 1. Correlation coefficient of DM yield with plant attribute, herbage quality and soil fertility across sites.

Year	Year after establishment	Plant attribute			Herbage quality		Soil fertility attribute		
		Height	PLB	Tiller	IVDMD	CP	N supply	Soil TN	Soil TC
2007	1	0.668*	-0.752*	0.925***	-0.212	0.110	0.793*	0.492*	0.265
2008	2	-0.388	-0.397	0.965***	0.038	-0.068	0.913*		

PLB: percentage of leaf blade, IVDMD: *in vitro* DM digestibility, CP: crude protein, TN: total nitrogen, TC: total carbon, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. (Source: Utamy *et al*. 2012).

Table 2. Herbage quantity and quality attributes of DL napiergrass in northern (GO) and central (KU) parts of Japan 18 and 16 weeks after planting, respectively.

Site	Plant height (cm)	Tiller density (/m^2)	Dry matter (kg/m^2)	Crude protein (mg/g)	TDN (mg/g)	ADF (mg/g)	NDF (mg/g)
GO (40.90ºN)	155.8	45.0	0.750	165	513	381	764
KU (36.11ºN)	157.0	81.4	1.825	122	546	442	716

competition severely hampered the early growth at Amakusa. The overwintering ability of DL napiergrass showed a threshold response to the lowest temperature of the winter season, when the critical temperature ranged from –6.2 to –7.5ºC under rotational grazing or cut-and-carry systems (Fig. 3). Thus, DL napiergrass can be used as a perennial in areas of southern Kyushu, where the minimum temperature never drops below the critical temperature, provided continuous grazing of the pasture is avoided.

Improvement of nursery production efficiency by vegetative nursery propagation (Experiment 3)

Propagation efficiency of nursery stem-cuttings was significantly higher in DL than other genotypes in autumn production in 2010 and spring production in 2011 (Fig. 4). However, the ordinary production (Od) which means production of rooted tillers was absolutely inefficient compared with the improved nursery production of stem-cuttings in multi-celled tray beds. Labour time did not vary among genotypes and was less than Od.

Suitability of DL napiergrass for northern and central parts of Japan (Experiment 4)

Plant height reached approximately 1.5 m 6-18 weeks after planting. The tiller density was almost twice as high in KU

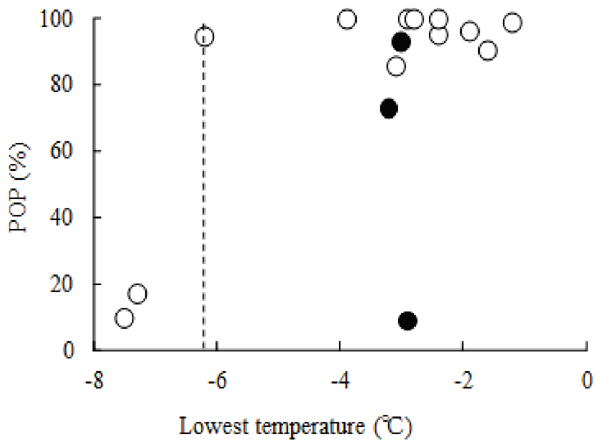

Figure 3. Relationship between percentage of overwintering plants (POP) of DL napiergrass and the lowest temperature in the winter season at 5 sites in southern Kyushu under rotational grazing or cut-and-carry systems (o) and under continuous grazing systems (●). Data was obtained from 5 sites/year from 2002 to 2006 from Ishii *et al*. (2013).

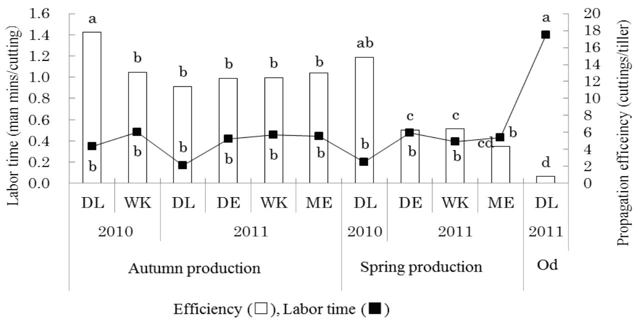

Figure 4. Labour time for producing nursery stem-cuttings and propagation efficiency of stem-cuttings per mother tiller for a range of napiergrass genotypes including DL napier grass

compared with GO due to a higher plant density. This translated to higher DM yield in KU. There were no significant differences in herbage quality attributes between the 2 sites and was satisfactory for an annual of tropical herbages (Table 2).

Conclusion

DL napiergrass exhibits a considerable herbage production capacity, producing highly palatable, good quality herbage. There is potential to increase its use as a perennial in southern Kyushu and as an annual in other areas of Japan.

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