JARQ 39 (4), 289 – 292 (2005) http://www.jircas.affrc.go.jp

Improvement of Seedling Growth and Forage Yield of Rhodesgrass (*Chloris gayana* Kunth) under Low Temperature Conditions

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Abstract

Five rhodesgrass (*Chloris gayana* Kunth) cultivars (Asatsuyu, Hatsunatsu, Katambora, Osumi-5, and Osumi-7) were evaluated for forage yield in a 3-year field experiment in the main island of Okinawa located in the subtropical region of Japan. The new cultivar Asatsuyu was significantly higher than the widely used commercial cultivar Katambora in dry matter yields at spring, fall and winter harvests during the second and third harvest years. Asatsuyu had significantly higher annual dry matter yields than Katambora and Hatsunatsu in the second and third harvest years. It was also significantly higher than Katambora and Hatsunatsu in total dry matter yield for 3 years. Annual dry matter yield showed significant positive correlation coefficients with dry matter yields harvested from winter to spring and from fall to early winter, suggesting that improvement of plant growth under low temperature conditions increases annual dry matter yield in rhodesgrass. In a growth room experiment at the National Institute of Livestock and Grassland Science in Tochigi, Asatsuyu was significantly higher in plant heights at 2, 3 and 4 weeks after seedling emergence and in dry matter weight at 4 weeks after seedling emergence than Katambora and Hatsunatsu at a low temperature (21/16ºC, day/night temperature). These results indicate that Asatsuyu has better performance than the other 2 cultivars at low temperatures. The results obtained in the field and growth room experiments show that the new cultivar Asatsuyu is superior to the other 2 commonly used cultivars Katambora and Hatsunatsu in seedling growth and forage production under low temperature conditions. The cultivar Asatsuyu can increase forage productivity and would extend periods of grazing and hay production in subtropical regions.

Discipline: Plant breeding / Grassland
Additional key words: 'Asatsuyu' rhodesgrass, dry matter yields, seasonal productivity

Introduction

Rhodesgrass (*Chloris gayana* Kunth) is an open-pollinated, perennial, tropical forage grass including both diploid (2n = 20) and tetraploid (2n = 40) forms[1]. The species is native to East Africa and has been widely cultivated in tropical, subtropical, and even warm-temperate regions of the world. It was introduced from Africa into Japan in the 1960s and is now one of the most important tropical forage grasses in the southern part of Japan. It is cultivated as a perennial in grasslands for grazing and hay production on the southern islands of Japan, including Okinawa. In this area, low winter temperature has been a major limiting factor for forage production due to substantially reduced growth in rhodesgrass. Therefore, improvement of plant growth in the winter season has been one of the most important breeding attributes in rhodesgrass.

The cultivar Hatsunatsu was developed at the Kyushu National Agricultural Experiment Station in Kumamoto, Japan and was registered in 1987. It was bred by maternal line selection from 42 strains introduced from Africa[6]. The cultivars Asatsuyu, Osumi-5 and

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Received 30 November 2004; accepted 1 March 2005.

Osumi-7 were developed at the Osumi Branch of the Kagoshima Prefecture Agricultural Experiment Station in Kagoshima, Japan. Asatsuyu was registered in 1995. It is a synthetic cultivar consisting of 7 clones selected from the cultivars Gunsons and Fords-Katambora[6].

This paper presents progress in the breeding of rhodesgrass in Japan for improving growth and forage yield under low temperature conditions.

Materials and methods

1. Field experiment

The field experiment was carried out at the Okinawa Prefectural Livestock Experiment Station in Okinawa, Japan (26º 41´N, 127º 57´E, 102 m a.s.l.). The mean annual rainfall in the area is 2,378 mm and the long-term mean annual temperature is 21.5ºC. Mean maximum and minimum monthly temperatures and total monthly rainfall from April 1991 to December 1993 are shown in Fig. 1. The mean minimum temperatures in February were 12.4ºC and 12.7ºC in 1992 and 1993, respectively, which were the lowest temperatures for the years. Total monthly rainfall over 3 years ranged from 30.0 mm to 331.5 mm. The soil at the experimental site is a gravel soil and is acid and low in organic matter.

Four Japanese cultivars, Asatsuyu, Hatsunatsu, Osumi-5 and Osumi-7, and one Australian cultivar, Katambora, were evaluated for their forage yield in 1991 to 1993. The 5 cultivars were sown at a rate of 10 kg/ha on 18 April 1991 in a randomized block design with 4 replicates. A plot consisted of 8 rows that were 3.0 m long, with 30 cm between rows. Before sowing, the experimental area received 5 t compost, 100 kg N, 100 kg P_2O_5 and 100 kg K_2O per ha. Fertilizer was also applied to plots at 100 kg N, 50 kg P_2O_5 and 100 kg K_2O per ha after each cut. The 6 rows (omitting the border rows on each side of the plot) of each plot were harvested 6 times in 1991 (13 June, 9 July, 25 July, 15 August, 10 September,

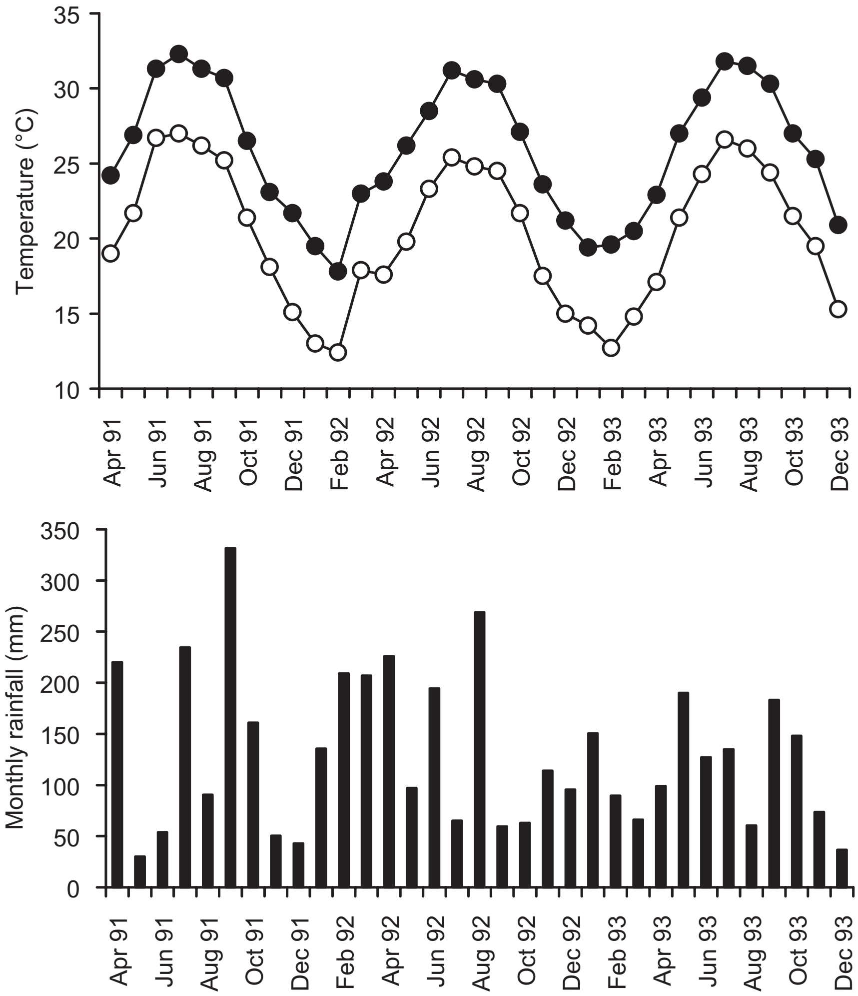

Fig. 1. Mean maximum (●) and minimum (○) monthly temperatures and total monthly rainfall from April 1991 to December 1993 in Okinawa

and 15 October), 6 times in 1992 (14 April, 3 June, 13 July, 1 September, 14 October, and 2 December) and 8 times in 1993 (13 January, 1 April, 11 May, 14 June, 19 July, 8 September, 26 October, and 20 December). At each harvest, the plots were cut at a height of 10 cm with a hand sickle, and the plant material was immediately weighed on a spring balance. Sub-samples from each plot were collected and dried at 72ºC for 48 h to determine percent dry matter.

2. Growth room experiment

The experiment was conducted at the National Institute of Livestock and Grassland Science in Tochigi, Japan. Three rhodesgrass cultivars, Asatsuyu, Hatsunatsu and Katambora, were evaluated for the seedling growth at a low temperature (21/16ºC, day/night temperature). Seeds from the cultivars were sown in 8 cm diameter pots containing local soil in an unheated greenhouse on 17 June 2003. A basal fertilizer containing N, P_2O_5 and K_2O was applied at 100 kg per ha for each nutrient. After thinning to 1 plant per pot on 25 June 2003, all plants of each cultivar were transferred to a growth room (21/16ºC, day/night temperature). Experimental layout was a randomized block design with 4 replicates of 12 plants.

Plant height and tiller number were recorded from 10 plants for each plot at 2 to 4 weeks after seedling emergence. At 4 weeks 10 plants for each plot were cut at the ground level to determine dry matter weight. The harvested materials were dried at 70ºC for 48 h.

Results and discussion

Since there was neither a significant difference among the cultivars in dry matter yields in the first harvest year nor a significant difference in summer periods in the second and third harvest years; these data are not presented in Table 1. During the second and third harvest years, Asatsuyu was significantly higher than Katambora in dry matter yield at spring, fall and winter harvests. Asatsuyu was also significantly higher than Hatsunatsu in dry matter yield at spring harvest in the second harvest year and at spring (on 1 April) and winter harvests in the third harvest year (Table 1). Asatsuyu had significantly higher annual dry matter yield than Katambora and Hatsunatsu in the second and third harvest years. These results suggest that a great improvement of the annual dry matter yield in Asatsuyu is attributable to its good winter and spring growth (Table 1). Hatsunatsu was significantly higher than Katambora in dry matter yields harvested on 13 January in the second harvest year and on 26 October in the third harvest year, but there was no significant difference between the cultivars in annual dry matter yields.

Asatsuyu was significantly higher than Katambora and Hatsunatsu in total dry matter yield for 3 years, indicating that Asatsuyu is highly productive in Okinawa and similar climatic regions. Sawai et al.[5] reported that Asatsuyu grew vigorously in cool seasons in southern Japan. Fukagawa et al.[2] reported that Asatsuyu was higher than Katambora and Hatsunatsu in winter survival and dry matter production and concluded that it is the most suitable cultivar of rhodesgrass in light-frost areas of the southern part of Japan.

Table 2 shows correlation coefficients between seasonal and annual dry matter yields of the 5 cultivars in rhodesgrass. The dry matter yield harvested from winter to spring showed significant positive correlation coefficients with that harvested from late spring to early summer and that from fall to early winter. The dry matter yield harvested from late spring to early summer showed a significant positive correlation coefficient with that harvested from fall to early winter, but it showed a significant negative correlation coefficient with that harvested

Table 1. Spring, fall, winter, and annual dry matter yields over 3 years in 5 rhodesgrass cultivars in Okinawa

Cultivar	Dry matter yield (t/ha)								Annual dry matter yield (t/ha)			
	2nd harvest year (1992)				3rd harvest year (1993)				1st harvest year (1991)	2nd harvest year (1992)	3rd harvest year (1993)	Total
	14 Apr	14 Oct	2 Dec	13 Jan	1 Apr	11 May	26 Oct	2 Dec				
Asatsuyu	5.5a*	4.2a	1.7a	2.3a	3.9a	4.8a	4.0a	3.0a	14.9	33.4a	29.1a	77.7a
Hatsunatsu	4.3bc	3.3abc	1.3ab	2.2a	2.9bc	4.0ab	3.3a	2.4bc	12.9	28.3bc	24.5bc	65.7cd
Katambora	4.0c	2.6c	1.0b	1.6b	2.6c	3.3b	2.4b	2.2c	13.1	27.2c	22.2c	62.5d
Osumi-5	5.4ab	3.7ab	1.6a	2.0a	3.7ab	4.2ab	3.2ab	2.5abc	14.7	31.9a	26.0b	72.6ab
Osumi-7	5.3ab	3.1bc	1.5a	2.0a	3.5abc	4.3ab	3.2ab	2.6abc	14.4	30.8ab	26.0b	71.2bc

*: Within a column, values followed by the same letter are not significantly different at the 5% probability level.

Table 2. Coefficients of correlation between seasonal and annual dry matter yields (DMY) over 3 years (1991–1993) in 5 rhodesgrass cultivars in Okinawa

	Winter-spring DMY	Late spring-early summer DMY	Summer-early fall DMY	Fall-early winter DMY
Late spring-early summer DMY	0.732**			
Summer-early fall DMY	–0.064	–0.631*		
Fall-early winter DMY	0.863**	0.842**	–0.248	
Annual DMY	0.839**	0.398	0.426	0.725**

* & **: Significant at the 5% and 1% probability levels, respectively.

Table 3. Seedling growth of 3 cultivars at low temperature (21/16ºC, day/night temperature)

Cultivar	Plant height (cm) at 2–4 weeks after seedling emergence			Tiller number/plant at 2–4 weeks after seedling emergence			Plant dry matter weight (mg/plant) at 4 weeks after seedling emergence
	2wks	3wks	4wks	2wks	3wks	4wks	
Asatsuyu	13.1a*	25.2a	42.5a	0.2	1.8	3.0	220.8a
Hatsunatsu	9.1b	19.3b	35.0b	0.1	0.7	2.7	137.5b
Katambora	9.6b	19.9b	34.1b	0.0	1.7	2.9	119.8b

*: Within a column, values followed by the same letter are not significantly different at the 5% probability level.

from summer to early fall. Annual dry matter yield showed significant positive correlation coefficients with that harvested from winter to spring and that from fall to early winter, suggesting that improvement of plant growth under low temperature conditions increases annual dry matter yield in rhodesgrass. There was no significant correlation between the dry matter yield harvested from winter to spring and that harvested from summer to early fall, suggesting that selection for improvement of growth in winter and spring does not have any adverse effect on summer or early-fall growth in rhodesgrass.

Ivory and Whiteman[3] reported that plant growth in rhodesgrass was greatly restricted by constant temperature of 10 or 15ºC and that an optimum temperature for total plant growth in rhodesgrass was 33.8/28.7ºC (day/night temperature). Kawanabe and Neal-Smith[4] found some genetic variation in the ability to grow at low temperatures in rhodesgrass. In our experiment, Asatsuyu had significantly higher plant heights than Katambora and Hatsunatsu at 2, 3 and 4 weeks after seedling emergence at a low temperature (21/16ºC, day/night temperature) (Table 3). Dry matter weight of Asatsuyu at 4 weeks after seedling emergence was also significantly higher than those of Katambora and Hatsunatsu at the low temperature, indicating that Asatsuyu has better performance than these cultivars at low temperatures (Table 3). However, there were no significant differences between cultivars in tiller numbers at 2, 3 or 4 weeks after seedling emergence (Table 3).

The results obtained in the field and growth room experiments show that the new cultivar Asatsuyu is superior to the other 2 commonly used cultivars, Katambora and Hatsunatsu, in seedling growth and forage production under low temperature conditions. The cultivar Asatsuyu can increase forage productivity and would extend periods of grazing and hay production in subtropical regions.

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