JARQ 39 (2), 105 – 108 (2005) http://www.jircas.affrc.go.jp

The Effect of Temperature and Daylength on Heading in Diploid Rhodesgrass Cultivars (*Chloris gayana* Kunth)

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Abstract

The present study was conducted to clarify the effect of temperature and daylength on heading in diploid rhodesgrass cultivars. Three diploid cultivars, Tochiraku-kei, Fords-Katambora and Pioneer, were planted 9 times at 10-day intervals between April 24 (I) and July 14 (IX) in 1975. In 1976 the 3 cultivars were planted 3 times at 1-month intervals on May 4 (II), June 4 (V) and July 4 (VIII) under 5 daylength treatments of natural daylength (ND), 12 h daylength (12 h), 24 h daylength (24 h), 24 h/ND, and 24 h/12 h. DH (days to heading) decreased linearly with the increase in DMT (daily mean temperature) commonly in the 3 cultivars in 1975, suggesting that temperature is a major factor determining DH in diploid rhodesgrass. This relationship is described by a linear regression equation between DH and DMT in the period from sowing to heading date. From the results in 1976, a short daylength is considered to have an effect for accelerating flower initiation of diploid rhodesgrass under temperatures more than 22ºC. These research findings would be useful in diploid rhodesgrass for estimating the first cutting time and/or seed harvesting time, and for conducting effective reproduction in greenhouses during winter.

Discipline: Plant breeding / Grassland
Additional key words: days to heading, flower initiation, photoperiod sensitivity

Introduction

Rhodesgrass, *Chloris gayana* Kunth, is a tropical forage grass originating in eastern Africa[3]. Rhodesgrass contains diploid (2n = 20) and tetraploid (2n = 40) forms[3,6]. Cultivars in both ploidy forms are now valuable for green fodder and hay in Japan[6,7].

Rhodesgrass is cut at each heading date for forage production and the panicles are harvested about 20 days after the flowering date for seed production[6,7]. Although the heading response to temperature and daylength is an important character for forage and seed production in rhodesgrass, studies on this response are limited to Bogdan[2], Tarumoto and Mochizuki[8], Oyama[5], Sato et al.[7], and Kokubu and Taira[4]. In these studies diploid cultivars were neutral to daylength[5]. Tetraploid cultivars were sensitive to daylength and their heading was induced by exposure to short daylength[3,5,8].

Breeding and forage production of rhodesgrass are now going on in Japan and therefore more accurate information is needed for the heading response under the climatic conditions in Japan. The present study was conducted to clarify the effect of temperature and daylength on heading in diploid rhodesgrass cultivars.

Materials and methods

In order to study the heading response of diploid rhodesgrass, I used 3 familiar cultivars in Japan, Tochiraku-kei, Fords-Katambora and Pioneer[1,6] (Table 1). Each of the seed lots was derived from propagation with open pollination in an isolated seed production field of the Nagano Branch, National Center for Seed and Seedling, MAFF, Japan[1]. Two experiments were conducted in 1975 and 1976 at the National Grassland Research Insti-

Outline of this work was presented at the 51st meeting (April 1977) of the Japanese Society of Breeding.

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Received 22 June 2004; accepted 5 November 2004.

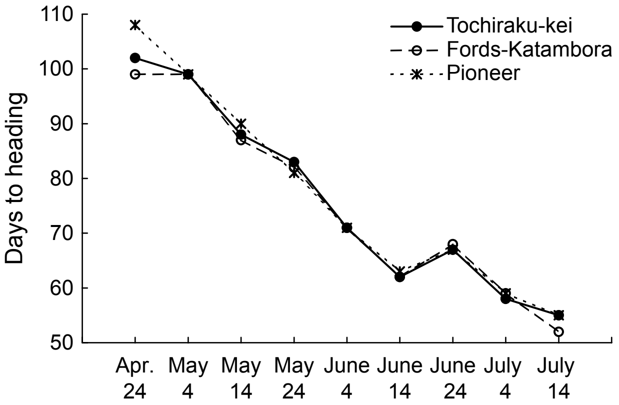

Fig. 1. Relationship between planting time and days to heading (DH) in 3 diploid rhodesgrass cultivars in 1975

tute (latitude 36°55′ N), Nishinasuno, Tochigi, Japan. In 1975, 3 cultivars were planted 9 times at 10-day intervals between April 24 (I) and July 14 (IX), as shown in Fig. 1. In 1976, they were planted 3 times at 1-month intervals on May 4 (II), June 4 (V) and July 4 (VIII), as shown in Table 3. Each of five 1/2000a pots was used for each cultivar and planting time, and seeds were directly sown in each pot and then thinned to 2 plants per pot at the 5th leaf stage in both years. In 1975, pots were set outdoors and plants were grown under natural temperature and daylength at Nishinasuno, Tochigi. In 1976, plants were grown under 5 daylength treatments by transferring pots according to Table 3. Days to heading (DH, hereafter) were recorded for each of the 10 plants per plot in both years.

Table 1. Cultivars, their origin and ploidy used in this study

Cultivar	Origin[a)]	Ploidy
Tochiraku-kei	Japanese local strain selected from a few African strains	Diploid 2x = 20
Fords-Katambora	Ecotype from South Africa	Diploid 2x = 20
Pioneer	African cultivar (cv. Commercial or Pioneer in Australia)	Diploid 2x = 20

a): Origin of the 3 cultivars was noted from the sources in Ubi et al.[9].

Table 2. Days to heading (DH) and daily mean temperature (DMT: X°C) in the period between planting and heading date in each planting time of 3 cultivars in 1975 and 1976, and Y[a)] estimated by DMT of each cultivar in 1975

Standard DMT	Tochiraku-kei			Fords-Katambora			Pioneer		
		1975	1976		1975	1976		1975	1976
(°C)	Y[a)]	DH[b)] (X,°C)[c)]	DH (X,°C)	Y	DH (X,°C)	DH (X,°C)	Y	DH (X,°C)	DH (X,°C)
18.0	141			134			151		
19.0	114	102 (19.1)	93 (18.8)	113	99 (18.9)	104 (18.9)	119	108 (19.5)	107 (19.2)
20.0	95	99 (19.9)		94	99 (19.9)		98	99 (19.9)	
20.5	88	88 (20.5)		87	87 (20.5)		90	90 (20.5)	
21.0	82	83 (21.3)	83 (21.2)	81	82 (21.3)	86 (21.1)	84	81 (21.2)	88 (21.0)
21.5	77	–	74 (21.7)	76	–	81 (21.4)	78	–	81 (21.4)
22.0	72	71 (21.9)		71	71 (21.9)		73	71 (21.9)	
22.5	68	62 (22.5)		67	62 (22.5)		68	63 (22.5)	
23.5	61	67 (23.3)		60	68 (23.3)		68	67 (23.3)	
24.0	58	58 (24.1)		57	59 (24.1)		58	59 (24.1)	
24.5	55	55 (24.6)		54	52 (24.6)		55	55 (24.6)	
25.0	53			52			52		
Difference between Y and DH :									
Mean		3.4	5.0		4.1	6.3		2.7	6.3
Range		0–12	1–21		0–14	5–9		0–11	3–12

a): Regression equation of Y (estimated DH) on X (DMT) was estimated from data of each cultivar in 1975.
Tochiraku-kei: $Y = 41.984/(0.071X - 1)$; Fords-Katambora: $Y = 41.419/(0.072X - 1)$; Pioneer: $Y = 39.293/(0.070X - 1)$, where Y is an estimated DH and X is DMT (°C) between planting and heading date.
b): DH observed in 1975 and 1976.
c): Values in parentheses show DMT observed in 1975 and 1976.

During the experimental period, at Nishinasuno, Tochigi (latitude 36°55′ N), daylength, including civil twilight, ranged from 14.7 (June 21, the summer solstice) to 12.8 h (September 7, the end of 1975 experiment) in 1975 and from 14.7 to 12.01 h (September 23, the end of 1976 experiment) in 1976. The daily mean temperature (DMT, hereafter) in the period between planting and heading date was noted in Table 2, and DMT of the later planting increased in both of 1975 and 1976 as shown in Table 2.

Results

The relationship between DH and planting time in 1975 is shown in Fig. 1. The DH decreased linearly with the delay in planting time, and the linear tendency was almost the same in the 3 cultivars. This result suggests that DMT is an important factor accounting for the heading response in diploid rhodesgrass cultivars.

DH, DMT and estimated DH (Y) in the period between planting and heading date are noted in Table 2, showing that the higher temperature accelerated flower initiation and decreased DH. The means of the differences between Y and DH were 2.7 to 4.1 days in 1975 and 5.0 to 6.3 days in 1976. The differences between Y and DH were generally small except for the ones in low DMT below 20ºC. From these results, temperatures, especially DMT, in the period between planting to heading date are also suggested to be a major factor for determining DH in diploid rhodesgrass cultivars.

The relationship between daylength and DH in 1976 is shown in Table 3. Although the 3 cultivars used in this study did not respond to 12 h daylength under low DMT below 20ºC for the planting time of May 4, Tochiraku-kei and Fords-Katambora responded to 12 h and 24 h/12 h treatments under DMT over 21ºC for the planting time of June 4. Under high DMT over 22ºC for the planting time of July 4, 3 cultivars remarkably responded to 12 h and 24 h/12 h treatments. DH at daylength treatments of 12 h and 24 h/12 h significantly decreased compared with DH at the treatments of 24 h, natural daylength (ND), and 24 h/ND. This tendency was observed commonly in the 3 cultivars. The results indicated that a short daylength has an effect on accelerating flower initiation of all the 3 diploid cultivars under temperatures over 22ºC as shown in Table 3.

Table 3. Relationship between daylength and days to heading (DH) in each cultivar in 1976

Planting time	Cultivar	Daylength treatment[a]				
		ND	12 h	24 h	24 h/ND	24 h/12 h
		DH (days to heading)				
May 4:	Tochiraku-kei	93 (18.8)[b]	99 (18.9)	97	98	96
	Fords-Katambora	104 (18.9)	100 (19.1)	105	100	101
	Pioneer	107 (19.2)	104 (19.2)	108	106	105
	Average	100 x[c]	101 x	103 x	101 x	101 x
June 4:	Tochiraku-kei	83 (21.2)	73 (21.0)	79	78	74
	Fords-Katambora	86 (21.1)	71 (21.0)	85	83	69
	Pioneer	88 (21.0)	81 (21.2)	85	83	76
	Average	86 x	75 yz	83 x	81 xy	73 z
July 4:	Tochiraku-kei	74 (21.7)	58 (22.3)	74	69	59
	Fords-Katambora	81 (21.4)	54 (22.6)	82	86	55
	Pioneer	81 (21.4)	60 (22.3)	86	86	70
	Average	79 x	57 y	81 x	80 x	61 y

a): Daylength treatment: Natural daylength (ND) ranged from 14.7 to 13.8 h for planting on May 4, 14.7 to 13.2 h for that on June 4 and 14.6 to 12.2 h for that on July 4, respectively. 24 h/ND: Started at 24 h daylength until the 5th leaf stage, and then changed to ND. 24 h/12 h: Started at 24 h daylength until the 5th leaf stage, and then changed to 12 h daylength.

b): Values in parentheses show DMT observed in 1976.

c): Values within the average column followed by the same letter are not significantly different at $P<0.05$.

Discussion

The DH decreased linearly with the delay in planting time and this linear tendency was almost the same in the 3 cultivars (Fig. 1). The result suggests that DMT is an important factor accounting for the heading response in diploid rhodesgrass. This is supported by the results of Table 2. The temperature in the period between planting to heading date, especially DMT, was the major factor for determining DH in diploid rhodesgrass. The regression equation, in which the estimated DH (Y) is negatively regressed with DMT (X), was effective for estimating DH in the corresponding cultivar[8] as shown in Table 2. These results mentioned above are the first findings of this kind in the world. The regression equation would become valuable for estimating the first cutting time in harvesting foliage and/or seed harvesting time in rhodesgrass reproduction.

Photoperiod sensitivity in rhodesgrass was reported in tetraploid cultivars[5,9], but not in diploid cultivars. The present study firstly revealed that diploid rhodesgrass cultivars showed photoperiod sensitivity to 12 h daylength under high DMT over 21ºC. The optimum daylength to flower initiation of summer gramineae crops like rice, maize and sorghum originating in the tropics is 12 h[10]. If 12 h might be the optimum daylength of diploid rhodesgrass cultivars originating in the tropics, the DH under daylengths less than 12 h would be the same regardless of DMT as that observed by Yanase and Tarumoto in sorghum[10]. Under 12 h treatment, however, DHs at the planting on June 4 (DMT: 21.0–21.2ºC) were longer by 15 to 21 days than at the planting on July 4 (DMT: 22.3–22.6ºC). Thus for diploid rhodesgrass, 12 h is not the qualitative short daylength like the optimum daylength. The above finding that the higher temperatures over 22ºC enhance the effect of short daylength for accelerating flower initiation in diploid rhodesgrass is considered to be useful for improving the efficiency of reproduction and cross-pollination in greenhouses during winter.

Acknowledgements

I express sincere thanks to Drs. K. Nakajima (Nihon Univ.), K. Nakashima (JICA expert) and the late M. Mochizuki for helpful discussion, and to all the assistant staff when I conducted the present studies as a research scientist at the National Institute of Grassland Science, Nishinasuno, Tochigi, Japan.

This work was supported by a special project of the Ministry of Agriculture, Forestry and Fishery of Japan.

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