Tillering in a bahia grass (*Paspalum notatum*) pasture under cattle grazing: results from the first two years

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Abstract

Tiller density, tiller appearance rate (TAR), tiller death rate (TDR) and tiller survival were measured for 2 years in a bahia grass (*Paspalum notatum*) pasture under cattle grazing. Total tiller density ranged from 3819 to 4791 tillers/m². TAR ranged from 0.21 to 35.42 tillers/m²/d (0.06–12.03 tillers/1000 tillers/d), being high from spring to autumn and low in winter. TDR ranged from 0.65 to 17.30 tillers/m²/d (0.16–3.79 tillers/1000 tillers/d) and was highest in summer and autumn and lowest in winter. The balance between TAR and TDR was highly positive in early summer and highly negative in early autumn in the first year. Thereafter, the trend was small and variable. Tillers formed in autumn survived longer (mean half-life = 856 d) than those formed in the other seasons (mean half-life = 433 d). The results indicate that bahia grass tiller density remains stable because tillers are long-lived despite low rates of tiller appearance.

Introduction

Permanent pasture is a major feed resource in grassland-based animal production systems. Persistence of pasture is a crucial factor in the sustainability of the systems. It is therefore important to understand the mechanisms behind the persistence of a pasture. In a grass pasture, persistence is largely dependent on the ability of the plant to maintain a high tiller density, which in turn depends on tiller appearance rate (TAR), tiller death rate (TDR) and longevity of individual tillers.

Bahia grass (*Paspalum notatum*), a sod-forming, warm season perennial, is widespread in the low-altitude regions of south-western Japan and used for both grazing and hay. It is well known that this grass forms a highly persistent sward which tolerates severe defoliation (Beaty et al. 1970, 1977; Stanley et al. 1977; Hirata 1993a, b; Hirata and Ueno 1993). However, little information is available about the tiller dynamics of this grass. Tiller densities under grazing (Hirakawa et al. 1985; Hirata et al. 1986) and in response to different cutting heights (Hirata 1993b) have been studied in bahia grass swards but none of these studies measured TAR, TDR and tiller longevity.

A study commenced in May 1996 to investigate tiller dynamics of bahia grass in terms of seasonal changes in TAR, TDR and survival of tillers under grazing with cattle. This paper presents findings from the study during the first 2 years.

Materials and methods

The site, pasture and animals

A 1.06 ha paddock of a bahia grass (cv. Pensacola) pasture at Sumiyoshi Livestock Farm (31° 59’N, 131° 28’E), Miyazaki University, Japan, was used for the study. The paddock was one of 5 paddocks (total area = 6.3 ha) rotationally grazed by Japanese Black cows from May to October.

In 1996 and 1997, the paddock was grazed 6 times by 28–33 animals (mean liveweight of 457 kg) with a 2–6 d duration (09.00-16.00 h each day) and 11–37 d intervals. The total duration of grazing was 22–23 d. This grazing man-
Tillering in a bahia grass pasture under grazing resulted in a relatively lenient grazing intensity.

In 1996, the paddock was fertilised with compound fertiliser and urea at 77 kg N (March and August), 20 kg P (March) and 30 kg K (March) per ha. In 1997, compound fertiliser equivalent to 45 kg N, 20 kg P and 30 kg K per ha was applied in April. The meteorological conditions are shown in Figure 1.

Figure 1. Monthly mean (a) maximum (—) and minimum (----) daily air temperatures, (b) total short-wave solar radiation and (c) rainfall during the study.
Measurements

Tiller dynamics of bahia grass were monitored from May 1996 to May 1998 in 8 randomly selected 20 cm × 20 cm permanent quadrats in the paddock. All live tillers within the quadrats were tagged on May 18, 1996 with a wire ring (9 mm in diameter) with a coloured bead at their base and grouped as the original tillers. This group consisted of tillers with different, unknown ages. Subsequent taggings were conducted at monthly intervals, when all quadrats were examined, any new tillers were tagged and the rings were removed from dead tillers. The number of new tillers tagged and the number of rings removed from dead tillers were recorded. Beads of a different colour were used at each tagging. The tillers were classified as dead when all parts were completely dried.

The tillers were classified into the following 9 age categories according to the period of their initiation, with category A being the original tillers: category A, pre-measurement (before May 18, 1996); category B, summer 1996 (May 19–August 19); category C, autumn 1996 (August 20–November 13); category D, winter 1996–1997 (November 14–February 14); category E, spring 1997 (February 15–May 13); category F, summer 1997 (May 14–August 15); category G, autumn 1997 (August 16–November 14); category H, winter 1997–1998 (November 15–February 15); category I, spring 1998 (February 16–May 18).

The proportion of tillers surviving (S) with time (t, days) was fitted by an exponential equation as:

\[ S = \exp(-bt) \]

where b is the decay constant (proportion/d). Then the half-life of tillers (t_{1/2}) (the time [d] taken for half the tillers to die) was calculated as:

\[ t_{1/2} = \ln 2/b \]

Herbage mass (above a 3 cm height) in the quadrats was estimated immediately before each tagging using an electronic capacitance probe (PastureProbe™, Mosaic Systems Ltd, New Zealand) (Hirata et al. 1993). Calibration equations were developed every 1–2 months by cutting samples from the paddock.

Results

Herbage mass

Herbage mass increased from spring to early autumn and decreased toward winter (Figure 2). The summer peak of herbage mass was higher in 1997 than in 1996.
Tiller density

Total tiller density, ranging from 3819 to 4791 tillers/m², increased during the first 2 months, decreased slightly in the next 2 months, and remained reasonably constant thereafter (Figure 3). Density of original tillers (category A) decreased with time and accounted for 34% of the final total tiller density. On the other hand, proportion of tillers appearing in the following seasons increased. Tillers formed in summer 1996 (category B), summer 1997 (category F), autumn 1997 (category G) and spring 1998 (category I) showed relatively high densities.

Tiller appearance and death rate

Seasonal patterns of TAR, TDR and their balance were similar on a per unit ground area basis and on a relative basis (Figure 4). TAR ranged from 0.21 to 35.42 tillers/m²/d (0.06–12.03 tillers/1000 tillers/d). It was high in early summer 1996, decreased until late autumn, and maintained low values during winter. Thereafter, it increased in spring, tended to level off during summer and autumn and fell again in winter. Seasonal means of TAR in summer, autumn, winter and spring were 12.14, 5.77, 1.82 and 6.01 tillers/m²/d (3.53, 1.50, 0.46 and 1.58 tillers/1000 tillers/d), respectively.

TDR ranged from 0.65 to 17.30 tillers/m²/d (0.16–3.79 tillers/1000 tillers/d). It tended to be high in summer and autumn and low in winter. Seasonal means of TDR in summer, autumn, winter and spring were 7.95, 8.17, 2.40 and 4.57 tillers/m²/d (1.82, 1.92, 0.59 and 1.21 tillers/1000 tillers/d), respectively.

The balance between TAR and TDR (TAR minus TDR) was highly positive in early summer 1996 and highly negative in early autumn 1996. Thereafter, the balance was small and variable in direction.

Tiller longevity

Tillers formed in autumn (categories C and G) survived longer (mean half-life = 856 d) than...
Figure 4. Tiller appearance rate (TAR), tiller death rate (TDR) and their difference on a per unit ground area basis (a) and on a relative basis (b). Vertical bars show s.e. of mean.

Figure 5. Survival of tillers initiated in the following seasons: summer 1996 ( ), autumn 1996 ( ), winter 1996–1997 ( ), spring 1997 ( ), summer 1997 (●), autumn 1997 (▲), winter 1997–1998 (▼) and spring 1998 (■).
Tillering in a bahia grass pasture under grazing

Discussion

This study has provided valuable information on tiller dynamics in bahia grass, showing it to have a very stable tiller density. Rate of tiller production is not great but the tillers are long-lived giving a very stable and persistent pasture.

Although the values and seasonal patterns of TDR would vary to some extent with factors such as climate, fertilisation rate and defoliation management, comparison of the present results with published data shows that bahia grass is characterised by low rates of tiller appearance and less sharp peaks in the seasonal pattern of TDR.

TAR in early summer 1996 was high. This may be attributable to the fact that the study site encountered a severe drought in the previous year and many tillers were killed (Hirata and Fuku-yama 1997). Thus, the high TAR is considered to reflect the stimulated tiller production to fill the empty space and does not reflect a long-term situation. When the extreme value (35.42 tillers/m²/d) was excluded, the mean summer TAR was 7.48 tillers/m²/d, similar to the values in spring (6.01 tillers/m²/d) and autumn (5.77 tillers/m²/d).

It has been reported that TAR ranged from 23 to 239 tillers/m²/d and from 2.9 to 9.2 tillers/1000 tillers/d in cut perennial ryegrass swards (Lolium perenne) (Korte 1986), and from 6 to 308 tillers/m²/d and from 2.1 to 48.9 tillers/1000 tillers/d in grazed swards (Chapman et al. 1983; Korte et al. 1984; Bullock et al. 1994; Garay et al. 1997), with highest values in summer (Chapman et al. 1983; Korte 1986; Bullock et al. 1994; Garay et al. 1997). In 2 grazed Agrostis species (Chapman et al. 1983; Jónsdóttir 1991; Bullock et al. 1994), Festuca rubra and Poa irrigata (Jónsdóttir 1991), TAR was in the range of 1.3−44.6, 0.8−8.8 and 0.0−9.3 tillers/1000 tillers/d, respectively, with highest values in summer in Agrostis species and in autumn in Festuca rubra and Poa irrigata.

The range in TDR of 0.65−17.30 tillers/m²/d (0.16−3.79 tillers/1000 tillers/d) with peaks in summer and autumn and troughs in winter contrasts with the 13−234 tillers/m²/d (0.9−14.9 tillers/1000 tillers/d) in cut perennial ryegrass swards (Korte 1986), and 7−79 tillers/m²/d (1.4−15.2 tillers/1000 tillers/d) in grazed swards (Korte et al. 1984; Bullock et al. 1994; Garay et al. 1997), with highest values in summer (Korte 1986; Garay et al. 1997). In grazed Agrostis stolonifera (Jónsdóttir 1991; Bullock et al. 1994), Festuca rubra (Jónsdóttir 1991) and Poa irrigata (Jónsdóttir 1991), TDR was in the ranges of 1.5−12.5, 0.7−5.2 and 0.0−7.0 tillers/1000 tillers/d, respectively. TDR was highest in summer in Agrostis stolonifera, and in autumn in Festuca rubra and Poa irrigata (Jónsdóttir 1991). Thus, bahia grass is characterised by low rates of tiller death and less sharp peaks in the seasonal pattern of TDR than in these other species. This is confirmed by the long half-life recorded for tillers in our study.

The half-life of bahia grass tillers (321−902 d) greatly exceeds the half-life of tillers of 36−143 d in cut perennial ryegrass (Korte 1986), and of 60−230 d in grazed perennial ryegrass (McKenzie 1997) (calculation by the present authors) and is similar to the 437−746 d in northern wheatgrass (Agropyron dasystachyum) (Zhang and Romo 1995) (calculation by the present authors). This long half-life in tillers is a critical factor in the stability of bahia grass swards.

The survival of tillers formed in autumn was superior to that of tillers formed in summer, winter and spring. The half-life of autumn tillers was approximately twice as long as that of summer, winter and spring tillers. This may be attributable to the fact that autumn tillers had less competition with parent tillers for nutrients and light, because autumn tillers initiated from reproductive tillers and replaced the space of reproductive tillers soon after they died. Death of
reproductive tillers can open sward canopy and may improve light and soil temperature conditions for daughter tillers. In addition, autumn tillers are considered to be able to utilise substrates in stolons of dead reproductive tillers, which also ensures survival (Matthew et al. 1989). Young daughter tillers are not independent of their parent tillers for nutrients and energy supplies (Ong 1978). Matthew et al. (1993) showed that daughter tillers from flowering tillers play a major role in the perennation of perennial ryegrass and prairie grass swards. Reproductive tillers in bahia grass are developed in summer.

Conclusions

Bahia grass commonly forms a highly persistent sward. This was confirmed by the constant total tiller density of 3819–4791 tillers/m² during our study. High stability of tiller density in a grass sward can be achieved with either of two contrasting strategies. One is to maintain high TAR and TDR with short-lived tillers, and the other is to maintain low TAR and TDR with long-lived tillers. The results of this study show that bahia grass employs the latter strategy.

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References


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