Response of Bahiagrass (*Paspalum notatum* Flügge) Sward to Cutting Height

4. Canopy structure and light extinction

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**Synopsis**


Canopy structure and light extinction within the canopy were investigated in bahiagrass (*Paspalum notatum* Flügge) swards subjected to different cutting heights, i.e. 2 (LL), 7 (L), 12 (M), 17 (H) and 22 (HH) cm above ground level. Swards under lower cutting heights were always more leafy and greener with less dead material. Extensive accumulation of dead material in M, H and HH swards modified light extinction within the canopy, due to absorption of radiation by dead material. In May, swards subjected to lower cutting heights showed higher leaf densities, with a greater part of leaves being distributed above non-photosynthetic organs, and less declines in radiation flux density with increased cumulative leaf area index. These canopy characteristics of severely defoliated swards in early growing season are considered to contribute to high tolerance of bahiagrass to close defoliation, through high light utilization efficiency for plant production. The results also imply that maintaining a bahiagrass sward short in winter to mid-spring (December-April) by closely defoliating the sward in autumn is an important sward management strategy leading to high quantity and quality of herbage and high tiller densities in early growing season.

**Key words**: Bahiagrass, Canopy structure, Cutting height, Light extinction.

**Introduction**

Bahiagrass (*Paspalum notatum* Flügge), a sod-forming, warm-season perennial, is widespread in the southern USA and Central and South America. It is also well adapted to the low-altitude regions of southwestern Japan and used for both grazing and hay. It is known that this grass forms a highly persistent sward which tolerates severe defoliation. The aim of this series of studies is to characterize the responses of bahiagrass swards to cutting height (2-22 cm above ground level) in terms of a number of quantitative and qualitative aspects of sward structure, production and utilization. The preceding 3 studies characterized the responses in terms of plant and litter mass, herbage yield and digestibility, and densities of tillers, stolons and roots. These studies confirmed that bahiagrass performs well even under the lowest cutting height, showing higher biomass of stolons and roots, higher densities of tillers, stolons and roots, and higher trends in spring herbage yields with decreased cutting height.

In the current study, we investigated the responses of bahiagrass swards to cutting height in terms of canopy structure and light extinction within the canopy. Our hypothesis was that modification of canopy structure and light extinction by decreased cutting height is one of the important mechanisms behind the high tolerance of bahiagrass to close defoliation.

**Materials and Methods**

1. The study site and experimental treatment

The study used Pensacola bahiagrass swards (area = 144 m²) at the Faculty of Agriculture, Miyazaki University, Japan (31°50′ N, 131°24′ E). From May 1986 to May 1989, the swards were under an experiment consisting of 5 cutting heights, i.e. 2 (LL), 7 (L), 12 (M), 17 (H) and 22 (HH) cm above ground level. The cuttings were made from May to November each year at 2-4 weekly intervals. Annual fertilizer rates were 20 g N, 14 g P₂O₅ and 12 g K₂O per m². Details of the experiment, meteorological conditions and major results have been described previously.

2. Measurements

Measurements were conducted on 10 occasions from May 1986 to May 1989 (the third year of the
Fig. 1a. Vertical distributions of densities of plant organs (columns) and relative radiation flux (O) in canopies of LL, M and HH swards in May-September 1988. Plant organs are leaves (laminae: leftward blank column), ears+stems (inclusive of leaf sheaths: rightward dotted column) and dead material (rightward cross-hatched column). Data from LL, M and HH swards are shown as examples.

experiment), i.e. 4 May, 8 June, 6 July, 3 August, 7 September, 6 October, 2 November 1988, 20 January, 12 April and 4 May 1989. Measurements in May-November were made one day before the regular cuttings. On each measurement occasion, an area of 20 cm × 20 cm, representative of each treatment sward, was selected, and the relative radiation flux density within the canopy of the area was measured at intervals of 2.5 cm in height from ground level, using a device measuring light levels above and within the canopy simultaneously (NS-II, Sansin Kogyo Co.). The flux density on the ground surface
was not measured because of the thickness (about 1 cm) of the probe. Then, sward samples were taken from the area using a stratified clip technique (2.5-cm layers from ground level). The samples were separated into ears, leaves (laminae), stems (inclusive of leaf sheaths) and dead material, and oven-dried (85°C for 72 hours) for dry weight determination after leaf area measurements.

3. Data analyses
The light extinction coefficient \( k \) within the sward canopies was calculated for each 2.5-cm layer as:

\[ k = (\ln I_u - \ln I_l) / L \]

where \( I_u \) and \( I_l \) are radiation flux densities at the upper and lower limits of the layer, and \( L \) is the leaf area index of the layer. The coefficient was not obtained for the bottom layers (0-2.5 cm layers because of no radiation flux density data on ground surface) and layers with no leaves.

Results
1. Canopy structure
Swards subjected to the 5 different cutting heights showed contrasting canopy structures. As shown by the examples from 3 swards (Figs. 1a and 1b), lowering cutting height decreased densities of non-photosynthetic organs (ears, stems and dead material), particularly dead material (LL < M < HH). Dead material always existed below the cutting height of the individual swards (≤ 2, 12 and 22 cm in LL, M and H swards, respectively). Another remarkable contrast in the canopy structure was seen in May. In this early growing season, lowering cutting height increased leaf densities (LL > M > HH), with a greater
part of leaves being distributed above non-photosynthetic organs. Thus, lowering cutting height produced more leafy and greener swards throughout the year.

2. **Light extinction**

Relative radiation flux density declined with depth in all canopies (Figs. 1a and 1b). In LL and L swards, the decline in the natural logarithm of relative radiation flux density was almost always linearly related to cumulative leaf area index throughout the profile (Fig. 2). By contrast, the relationship in M, H and HH swards usually deviated from linearity at depth of the canopy. The slope (absolute value) of the linear section of the relationship increased as the cutting height increased in April and May (LL<M<H<HH), whereas it was relatively constant across the cutting heights in other months (LL=L=M=H=HH).
canopy layers increased as the density of dead material relative to leaves in the layers increased ($r=0.915$, $P<0.001$; Fig. 3).

**Discussion**

The preceding 3 studies confirmed that bahiagrass performs well even under the lowest cutting height, showing higher biomasses of stolons and roots\(^5\), higher densities of tillers, stolons and roots\(^7\) and higher trends in spring herbage yields\(^5\) under decreased cutting height. Our hypothesis in the current study was that modification of canopy structure and light extinction by decreased cutting height is one of the mechanisms behind the high tolerance of bahiagrass to close defoliation.

Both canopy structure and light extinction showed considerable responses to cutting height. Swards subjected to lower cutting heights were always more leafy and greener with less dead material (Figs. 1a and 1b). In agreement with this, digestibility of herbage was almost always higher in swards subjected to lower cutting heights\(^6\). The accumulation of dead material below the cutting height (Figs. 1a and 1b) is attributable to senescence and death of undefoliated or unutilized leaves and stems. ETHEREGE\(^3\) also observed that bermudagrass (*Cynodon dactylon*) swards were more leafy and greener under closer defoliation.

The extensive accumulation of dead material in M, H and HH swards modified light extinction within these sward canopies; *i.e.* the decline in the natural logarithm of relative radiation flux density with increasing cumulative leaf area index usually deviated from linearity at depth of the canopy (Fig. 2), mainly due to the absorption of radiation by dead material (Fig. 3). LUDLOW et al.\(^8\) reported a similar phenomenological decrease in canopy absorbance due to light absorption by stems in setaria (*Setaria sphacelata*) and pangola grass (*Digitaria decumbens*).

However, the absorption of radiation by dead material in M, H and HH swards may not greatly reduce the absorption by leaves during the major growing season of June-October, because the absorption by dead material occurred in lower layers with few leaves after radiation was largely absorbed by leaves in upper layers (Figs. 1a, 1b and 2).

Modification of canopy structure and light extinction that may support our hypothesis was obtained in May. In this early growing season, swards subjected to lower cutting heights showed higher leaf densities, with a greater part of leaves being distributed above non-photosynthetic organs (Figs. 1a and 1b). Furthermore, in swards under lower cutting heights, the radiation flux density declined less sharply as it passed through layers of a unit leaf area index (Fig. 2). These canopy characteristics of severely defoliated swards favor the light utilization efficiency for gross production in plants, and thus may contribute to the high tolerance to close defoliation.

The favorable spring canopy characteristics achieved by decreased cutting height, together with results from previous studies\(^5,7\), imply that maintaining a bahiagrass sward short in winter to mid-spring seasons (December-April) is an important sward management strategy leading to high quantity and quality of herbage and high tiller densities in early growing season (May). Although this can be achieved by closely defoliating the sward in autumn, the time of close defoliation may need to be determined taking account of the time when bahiagrass plants translocate reserve substances stored in stems during summer into stolons and roots before the dormant winter season\(^4,6\).

**References**


平田昌彦・江口浩司・高吉哲生・長船志帆・興松希代子・山本奈美（2002）：バヒアグラス（Paspalum notatum Flügge）草地の刈取り高さに対する反応。牧草 48, 326-331。宮崎大学農学部（889-2192 宮崎市学園木花台西１-１）

異なる刈取り高さ（2-22 cm）で管理されたバヒアグラス（Paspalum notatum Flügge）草地の草冠構造と光の減衰について調査した。低刈下の草地は常に緑葉割合が大きく、枯死部割合が小さかった。生育期間初期（5月）には、低刈下の草地ほど、葉が密で、その多くが非光合成器官より高い位置に分布し、吸光係数が小さく、これらの特質が、植物総生産の光利用効率の増加を通じて、高い刈取耐性に寄与するものと考えられた。また、秋の低刈により冬から春にかけて草地を低く維持することが、生育期間初期の草冠と草冠ならびに分けつ密度を増加させるために重要な草地管理方法であることが示唆された。

キーワード：刈取り高さ、草冠構造、バヒアグラス、光減衰。