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Vertical distribution of leaf area, dry matter and radiation in grass-clover mixtures

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Summary

The large-leaved white clover cv. Alice and the small-leaved cv. Gwenda were grown in combination with perennial ryegrass cv..Condesa in the field at two cutting frequencies. The spatial and temporal rate of change in leaf area, dry matter and radiation absorption were studied at weekly intervals in successive 5-cm canopy layers. In the regrowth period from 26 July to 15 August in both mixtures ryegrass was overtopped by clover after 3 weeks. Subsequently, in the mixture with the large-leaved clover a larger proportion and a larger absolute amount of the clover LAI and dry matter were observed at a greater height in the canopy than in the mixture with the small-leaved clover. These differences led to a better absorption of light and a higher dry matter yield in the large-leaved mixture under cutting. At the end of the regrowth period total clover dry matter yield and LAI were higer in the large-leaved mixture, but the total grass dry matter yield and LAI were similar.

Keywords: canopy structure, dry matter distribution, *Lolium perenne*, *Trifolium repens*.

Introduction

Under optimal production conditions in which water and nutrients are amply available, competition in mixtures is mainly determined by radiation, temperature and species characteristics (Kropff & van Laar, 1993). The outcome of competition for light absorption in grass-clover mixtures depends on the canopy structure (Johnson *et al.*, 1989). Canopy structure determines the fraction of leaf area of the species that is in the better position to intercept radiation (Woledge *et al.*, 1992). Canopy structure and the ability of species to capture light are influenced by management (cutting or grazing) and by their growth habit (Parsons *et al.*, 1991). For example, under a cutting management the clover yield in grass-clover mixtures has been found to be positively correlated with clover leaf size (Evans & Williams, 1987). The nature of the effects of management and growth habit can be understood by detailed study of the patterns of leaf, light and dry weight distribution and their changes in time. However, there is little information about the time course of dry matter (DM) and leaf area distribution in mixtures of grass and clover with different growth habits. This study reports on the difference in vertical distribution of leaf area, DM and light profiles in contrasting grass-clover mixtures during successive regrowth periods after cutting.

Materials and Methods

The experiment was carried out on mixtures which were established in April 1991 on heavy river clay at Wageningen (Elgersma *et al.*, 1994). Measurements started in June 1995 with 2 cutting frequencies (about 1200 and 2000 kg DM ha^{-1}, F1200 and F2000 respectively) as main plots and 2 grass-clover mixtures as sub-plots in a split-plot design with 3 replicates. The tetraploid grass cv. Condesa was grown with the clover cv. Alice (large-leaved) or cv. Gwenda (small-leaved) (CA and CG respectively). The plots were cut with a Haldrup harvester to 5 cm sward height. Absorbed PAR (photosynthetically active radiation) was measured weekly in the canopy from top to ground level at successive 5-cm layers from the start of each regrowth period until the next cut at 10 randomly chosen positions in each plot. The vertical distribution of leaf area in the canopy was measured weekly using an inclined point quadrat (Warren Wilson, 1963). All contacts with the point on 20 descents in each plot were recorded for clover leaf blade, clover petiole and grass (blade and sheath). At weekly intervals all plant material in a 10x10 cm quadrat was harvested from ground level and cut in successive 5-cm layers. Each layer was separated into clover blade, clover petiole, grass blade and grass sheath and dried at 70°C for 24 hours.

Results

Measurements started in June and continued until October 1995. There were 7 regrowth periods for F1200 and 5 for F2000. The results of one regrowth period (4 weeks), from July 26 to August 15, in F1200 are presented here.

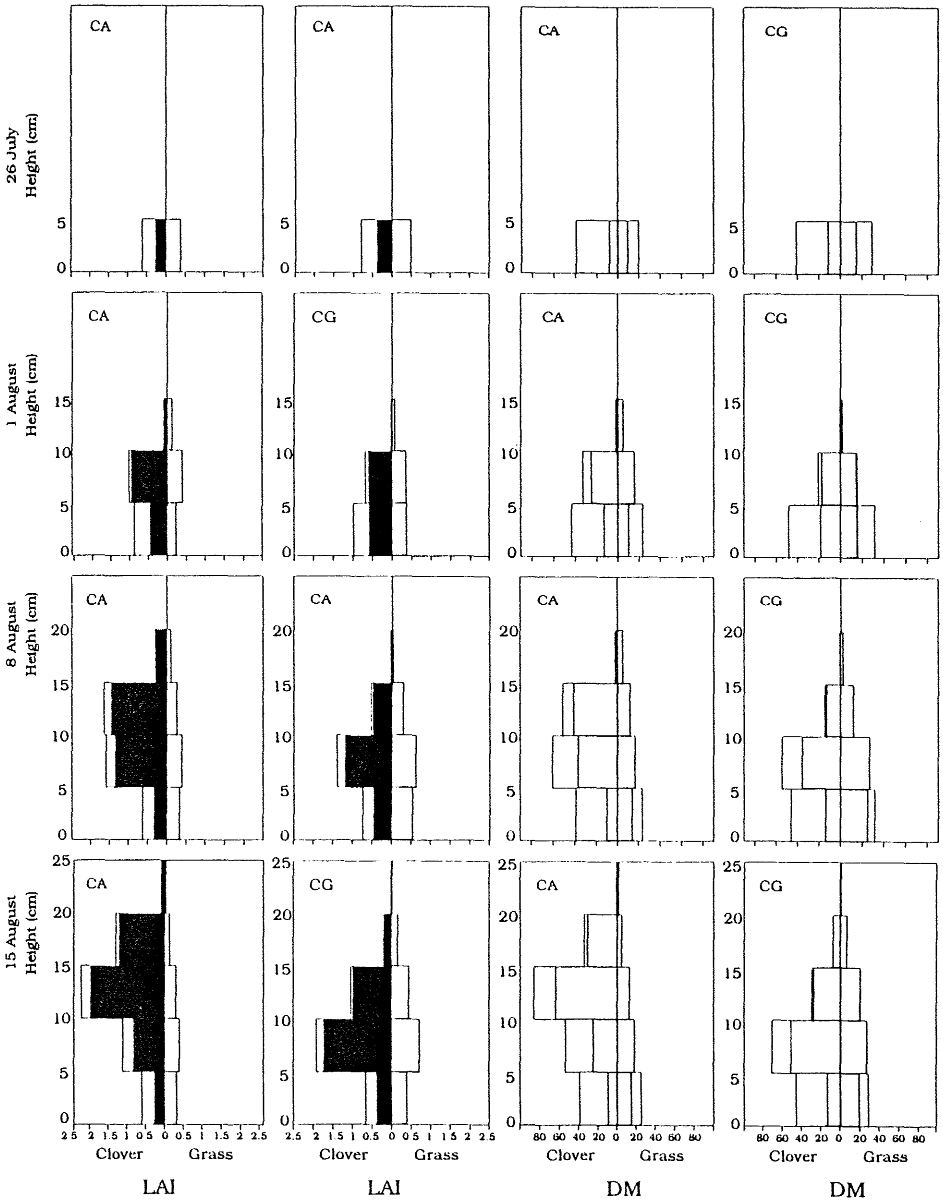
Canopy structure

Figure 1 shows the vertical dynamics of leaf area index (LAI) for both mixtures. At the start of the regrowth period there were no significant differences in grass or clover LAI between the mixtures. After one week of regrowth, the total LAI and the LAI of the top layer in cv. Alice were significantly higher than in cv. Gwenda, but for grass the differences in LAI between layers were not significant. In the third week of regrowth the canopy structures of the two mixtures were quite different. In CA 49 % of the total clover LAI was observed above 10 cm height, while in CG 78 % of the clover LAI was concentrated below 10 cm. These differences in leaf area distribution were most pronounced at the end of the regrowth period. After 4 weeks of regrowth the total LAI and the LAI of layers 15-20 and 10-15 cm were significantly different between the mixtures. The total grass LAI (0-25 cm) was not significantly different in CA and CG (1.4 and 1.1, respectively). However, the total clover LAI in CA (4.3) was significantly higher than in CG (3.4).

DM distribution

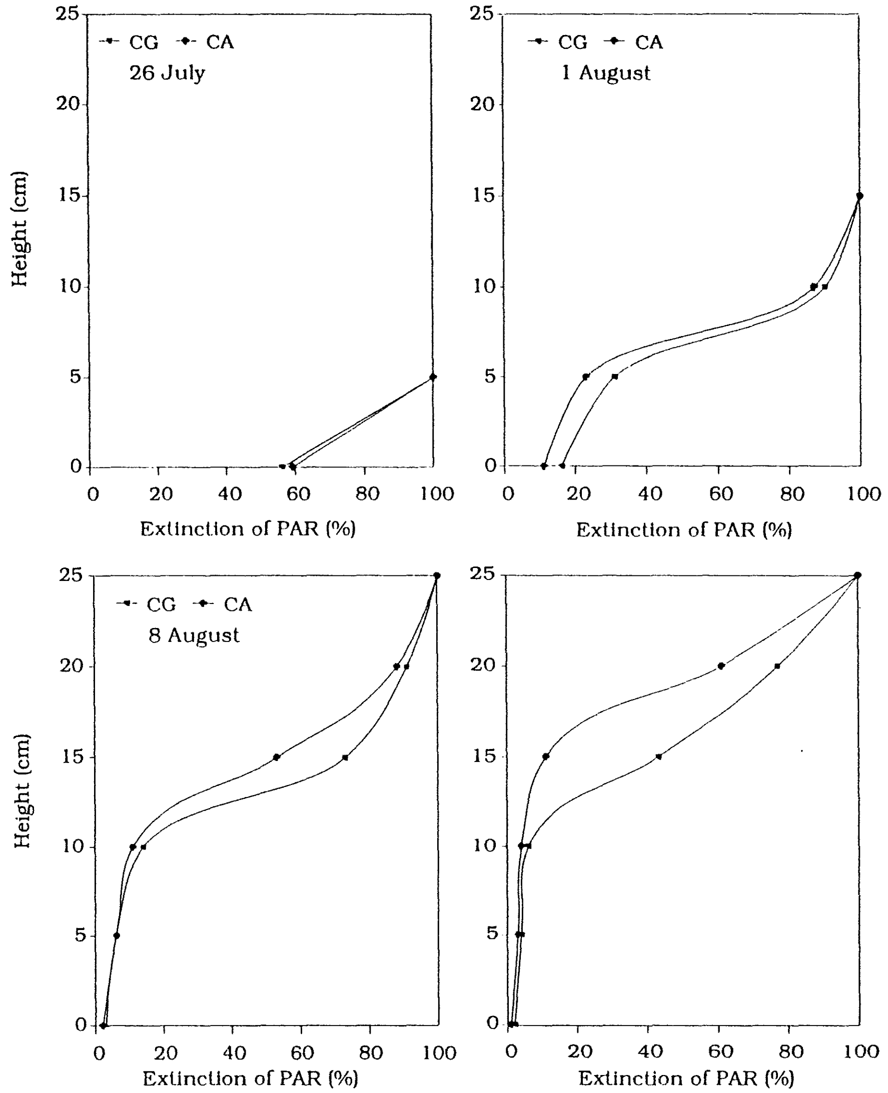
The pattern of DM distribution was similar to that of the leaf area indices (Figure1). The total DM was significantly higher in CA. However, the contribution of grass to the total DM of CG was greater than in CA. The vertical distribution of DM shows that it accumulated in higher sward layers in CA than in CG (Figure 1). This difference became clear from the third week of regrowth and became highly significant in the fourth week. At the end of the regrowth period the maximum DM of grass and clover in CG occurred at the same layer (5-10 cm), while in CA the maximum DM of

Figure 1. Vertical distribution of LAI and DM (g m⁻²) during 4 weeks of regrowth: grass lamina, light bars; grass sheath, black bars; clover lamina, light bars; clover petiole, black bars. CA=Condesa-Alice; CG=Condesa-Gwenda.



clover was found one layer higher (10-15 cm) than the maximum DM of grass. After 3 weeks of regrowth the petiole DM in the 5-10 cm layer was significantly higher in CA than in CG (Figure 1). This caused the clover leaf area (and DM) of CA to shift to a higher layer in the next week of regrowth (Figure 1).

Figure 2. Extinction of PAR in the canopy during 4 weeks of regrowth.



At the end of the regrowth period the total grass DM was not significantly different in CA and CG (61.9 and 73.3 g m^{-2}, respectively). However, total clover DM was significantly higher in CA (175.9 g m^{-2}) than in CG (138.8 g m^{-2}). Clover was found one layer higher (10-15 cm) than the maximum DM of grass. After 3 weeks of regrowth the petiole DM in the 5-10 cm layer was significantly higher in CA than in CG (Figure 1). This caused the clover leaf area (and DM) of CA to shift to a higher layer in the next week of regrowth (Figure 1). At the end of the regrowth period the total grass DM was not significantly different in CA and CG (61.9 and 73.3 g m^{-2}, respectively). However, total clover DM was significantly higher in CA (175.9 g m^{-2}) than in CG (138.8 g m^{-2}).

Light profile

Light extinction had a similar profile to canopy structure. During the first two weeks of regrowth, light had the same profile in both mixtures (Figure 2). However, large and significant differences appeared from the third week, as the same time as the differences in canopy structure increased (Figure 1). In the CA sward the critical LAI (that at which 95% of the light is intercepted (Thomas, 1980)) occurred at 15 cm height, which was 5 cm higher than the critical LAI in CG (Figure 2).

Discussion

In this study an attempt was made to find an ecophysiological basis for interactions in grass-clover mixtures under cutting. Elgersma *et al.* (1994) reported a higher total DM and a higher clover yield in mixtures with cv. Alice than in mixtures with cv. Gwenda, when grown with the same grass cultivar. There was no effect of clover cultivar on grass yield. This study showed that both clover cultivars had a higher proportion of their LAI in top layers in comparison to grass and in both mixtures during summer grass was overtopped by clover. The degree of this overtopping was much higher in mixtures containing cv. Alice. This was mainly due to the better canopy structure and greater petiole length which enabled cv. Alice to capture light more efficiently. The results also show that even in the small-leaved clover cultivar during the summer period grass had no advantages. In agreement with Woledge *et al.* (1992), not only large-leaved clover cultivars but also small-leaved cultivars had superiority over grass during the main growing season under cutting. This work will be continued with a dynamic simulation study of the interactions in grass/clover mixtures under cutting.

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