PERSISTENCE OF A LARGE LEAVED WHITE CLOVER VARIETY UNDER SHEEP GRAZING

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Abstract

Measurements of photosynthesis. leaf appearance, leaf death and clover stolen characteristics were made during late summer on an established mixed perennial ryggrass (\$24) white clover (Blanca) sward continuously grazed by sheep to maintain sward heights of either 2-3cm (hard grazed) or 10-15cm (lax grazed). In both hard and lax grazed swards, each \$t0\0n tip had three petioles on average, and a new leaf appeared and an old leaf (petiole) died every seven days. Under intensive grazing, new clover leaves were grazed within 1-2 days of appearance, sometimes before leaflets had unfolded, leaving only petioles on the stolon. The contribution of clover leaflets to the gross photosynthesis of the sward was greater than would be expected from their contribution to the total leaf area. The photosynthesis of petioles was appreciable, though some 25% that of leaves on an area basis. Although white clover became more prostrate and smaller leaved under hard grazing, the adaption was insufficient to prevent most photosynthetic tissue being grazed. The results are discussed in relation to white clover persistence.

Keywords: White clover, stolons, leaf size, leaf appearance, photosynthesis, continuous grazing.

INTRODUCTION

The main morphological feature used to distinguish white clover (*Trifolium repens* L.) cultivars are differences in size of plants and their individual parts (Hawkins, 1959). The medium to large leaved types (e.g.; Blanca, 'Grasslands Pitau') have relatively large leaflets and petioies, long stout stolons which form a relatively open network. By contrast, the small leaved types (e.g.; S184, 'Grasslands Tahora') have smaller organs and form a dense network of multi-branched stolons. 'Grasslands Huia' is an intermediate type, classified as medium to small leaved in the United Kingdom.

Generally, under intensive sheep grazing in Britain the smaller leaved types are more likely to persist than the large leaved types (Jenkin, 1955). Curll & Wilkins (1981) demonstrated that the modern large leaved cultivar, Blanca, failed to persist under intensive continuous sheep grazing. However, as large leaved cultivars are considered to have other valuable agronomic characteristics, notably higher yields (Aldrich, 1970; Laidlaw, 1980; Frame et a/. 1982) and possibly a greater tolerance to nitrogen fertiliser (Davis, 1969; Aldrich, 1970), a study was conducted to identify possible reasons for poor persistence under intensive sheep grazing. The results have relevance to New Zealand hill country pastures, where Pitau and Huia fail to persist as well as the small leaved Tahora (Williams, eta/. 1981).

METHODS AND MATERIALS

During summer 1982, an established mixed sward of S24 perennial ryegrass/Blanca white clover was divided into two initially similar grazing areas, each *Agronomy Department, Massey University, Palmerston North (on sabbatical leave at G.R.I.)

 $30m \times 44m$, then continuously grazed by sheep to maintain contrasting mean sward surface heights of either 2-3cm (hard grazed) or IO-1 5cm (lax grazed). Stock numbers were adjusted as required to maintain the difference and both areas were topped in June to remove patches of grass flowering stems. The swards were irrigated to keep the soil water deficit less than 25mm.

Measurements began two months after the start of the grazing treatments when the swards had adjusted to the treatments. At two-week intervals, from each grazing area, six herbage samples (each 25cm x 50cm) were cut to ground level using scalpels. Measurements included herbage mass, leaf area, tiller number, stolon tip (growing point) number and stolon length. Both terminal buds and actively growing axillary buds were counted on clover stolons. Separate \$10|00 samples, four per grazing area and each of 30-50 stoions, were carefully removed to determine the number of leaves per stolon and size of ungrazed clover leaves. The rate of leaf appearance and death for white clover was determined from twice weekly observation of marked leaves on 60 tagged stolons per grazing area. The contribution of grass and clover, and their parts, 'co canopy photosynthesis was measured on four occasions by exposing a $0.25 m^2$ area of sward to $^{14}\,CO_2$ for five minutes in a perspex enclosure. A sample of exposed herbage was then cut to ground level with a scalpel, separated into components, dried, weighed and radio-activity measured. The photosynthetic 'effectiveness' of herbage components in situ was calculated from their contribution to the gross photosynthesis of the whole canopy, divided by their projected area. Canopy photosynthesis was measured using the equipment and techniques described by Stiles (1977).

RESULTS

The weight and composition of herbage remained relatively constant during the measurement period (20 July ~ 15 September). The main difference between swards at all samplings was the amount of white clover, i.e. 470 and 2010 kg DM/ha, or 12% and 36% of herbage in the hard and lax grazed area respectively (Table 1). The amount of grass and dead herbage was similar in both swards. Almost three times more grass tillers were present in the hard than the lax grazed area. Although the number of stolons was greater in the former sward on average, the trend was not statistically significant or consistent for all samplings. The total length of stolons per unit area and per individual stolon were both considerably greater in the lax than the hard grazed area.

Each stolon tip had approximately the same number of petioles in both swards, but the leaves were larger and fewer were grazed in the lax than the hard grazed sward (Table 2). The difference in sward length was apparent from the difference in petiole length.

Between 20 July and 20 August in both swards, the rate of clover leaf appearance equalied the rate of leaf death, a new leaf appearing and dying on each stolon every 6.6 \pm 0.2 days. Some tagged stolons in the hard grazed sward had no leaflets and new leaflets were grazed within 1-2 days of appearance, sometimes before leaflets had unfolded, leaving only petiole bases on the stolon.

Grass lamina and clover lamina were the main photosynthetic tissues, accounting for 93% and 73% of $^{14}\,\mathrm{CO}_2$ fixation in the hard and lax grazed swards respectively. (Table 3). Despite the contribution of grass sheath to photosynthetic surface, it contributed little to photosynthesis. Clover lamina was considerably more effective photosynthetically (per unit area of tissue) than grass lamina. In

Table 1: HERBAGE MASS, LEAF AREA INDEX, TILLER NUMBER, STOLON NUMBER AND STOLON LENGTH IN EACH GRAZING AREA. MEAN OF FIVE SAMPLING DATES.

	Hard i∕lean SE	Lax Mean SE
kg Divi/ha		
Grass	1,580 ± 140	1,540 ± 210
Clover	470 ± 100	2,010 ± 210
Dead Herbage	1,870 ± 150	1,960 ±220
Total	3,920 ± 80	5,510 ± 320
LAI	1.5 ± 0.1	3.9 ± 0.4
Tillers/m²	22,200 ± 2,100	$7,800 \pm 900$
Number of stolons/m ²	4,100 ± 800	3,100 ± 400
Stolon length (m/m²)	60 ± 11	108 ± 18

Table 2: NUMBER OF PETIOLES PER STOLEN, LENGTH OF UNGRAZED CLOVER PETIOLES, AND WEIGHT OF INDIVIDUAL CLOVER LEAF-LETS AND PETIOLES ON UNGRAZED EXPANDED LEAVES.

	Hard		Lax	
	Mean	SE	Mean	SE
Petioles per stolon				
Grazed"	1.3	0.1	0.6	0.2
Ungrazed	1.6	0.2	2.0	0.2
Total	2.9	0.2	2.6	0.3
Petiole length (cm)	1.7	0.1	9.8	0.7
Weight (mg)				
Leaflet	2.0	0.2	3.2	0.8
Petiole	1.5	0.3	7.6	1.9

^{*} No leaflets

the hard grazed sward clover petioles were 40%. and clover stolens 7%, as effective as clover lamina in photosynthesis. All sward components had a greater photosynthetic effectiveness on a unit area basis in the hard than the lax grazed sward.

DISCUSSION

In this experiment herbage was cut to ground level with scalpels to ensure that stolons were harvested, but this undoubtedly resulted in higher herbage mass and dead matter values than would be obtained using clippers or shears.

However the results are consistent with those of others using this technique (Jones et a/. 1982; Parsons et a/. 1983).

Table 3: CONTRIBUTION OF GRASS AND CLOVER FRACTIONS TO THE PROJECTED AREA, $^{14}\,\text{CO}_2$ FIXATION OF THE SWARD AND THE CALCULATED GROSS PHOTOSYNTHETIC EFFECTIVENESS AT 400 W/m² (g CO $_2/\text{m}^2$ projected area/hr). MEAN OF 4 SAMPLES \pm SE.

	% area	% ¹⁴ C	Effectiveness
Hard grazed sward			
Grass			
Lamina	53 ± 2	73.8 ± 5.0	1.86 ± 0.29
Sheath	25 ± 6	2.4 ± 0.7	0.12 ± 0.02
Clover			
Lamina	12 ± 3	19.6 ± 4.3	2.69 ± 0.43
Petiole	6 ± 2	3.7 ± 1.1	1.09 ± 0.32
Stolon	4 ± 1	0.1 ± 0.1	0.18 ± 0.05
Flowers'		0.4 ± 0.2	
Lax Grazed Sward			
Grass			
Lamina	45 ± 4	39.3 ± 7.2	0.58 ± 0.09
Sheath	11 ± 2	1.5 ± 1.1	0.07 ± 0.04
Clover			
Lamina	28 ± 3	54.1 ± 6.3	1.32 ± 0.17
Petiole	12 ± 1	5.0 ± 1.o	0.27 ± 0.04
Stolon	4 ± 1	-	0.01 ± 0.003
Flowers'		0.1 ± 0.1	

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Compared with lax grazing, hard grazing markedly reduced the proportion of clover by weight in the sward, a similar result to that obtained in agronomic studies in the United Kingdom (Marsh & Laidlaw, 1978; Curll & Wilkins, 1981). In this experiment the reduction was mainly due to a reduction in the weight of leaflets, petioles and internodes on each stolon. The number of leaves (petiolesi per stolon and the number of stolons per unit area were little affected by the grazing treatments. These results are consistent with those of King et al. (1978) who found that defoliation of white clover plants caused a reduction in the size of leaflets, petioles and internodes, the reduction being greater with more severe defoliation. As a result of these differences, the same variety of white clover showed markedly different habits of growth in the two grazing areas. Plants were compact and prostrate under hard continuous grazing but had free running, loosely rooted stolons, and a more erect habit of growth with lenient grazing, These two contrasting habits of growth with different grazing intensities were also observed by Harris & Brougham (1968).

In established swards, perennial Tyegrass tillers generally have 2-3 leaves, with

the rate of leaf appearance balancing the rate of leaf death and all three parameters being little influenced by grazing (Davies 1977; Jones et al. 1982; Parsons et al. 1983). White clover stolons also had approximately three leaves, with leaf appearance again balanced by leaf death, and all three parameters little influenced by grazing. These results are consistent with other studies of white clover under more controlled conditions (King etal. 1979; Davies & Evans, 1982). The number of live leaves per stolon may decrease in winter however, when leaf appearance can be restricted by lowtemperatureand light levels (Haycock, 1981).

The horizontal orientation of clover leaflets at the top of the sward was undoubtedly the main cause of their higher photosynthetic effectiveness than the more erect ryegrass leaves (Monteith, 1965). Ryegrass leaves and clover leaflets have similar photosynthetic rates at the same light intensity when the angle of incidence is similar (Woledge & Dennis 1982). Although the data for that hard grazed sward (Table 3) indicated that clover petioles were 40% as effective as leaflets in photosynthesis, subsequent research has shown that a value of 25% is more realistic. In this study a small amount of radioactive ¹⁴ C would have been translocated from leaflets to petioles during the period from the start of exposure to the end of herbage separation (Ryle et al. 1981).

Although a greater photosynthetic effectiveness was measured in the hard than the lax grazed sward (Table 3), the difference did not compensate for differences in leaf area and light interception, so that canopy photosynthesis was greater in the latter sward. The greater photosynthetic effectiveness in the former sward mainly reflected better illumination of leaves and a higher photosynthetic efficiency of individual leaves (Woledge, 1978).

efficiency of individual leaves (Woledge, 1978).

The pattern of leaf growth and defoliation observed on leafless tagged stolons in the hard grazed sward indicated why large leaved types of white clover fail to persist under intensive sheep grazing in the U.K. Leaflets sometimes only contributed to photosynthesis for I-2 days before being eaten on such stolons. As both petioles and stolon had low photosynthetic rates, the supply of current assimilates for growth and respiration was limited for 5-6 days until a new leaf appeared on leafless stolons. If such defoliation was maintained for long periods over the whole sward, stolons and eventually whole clover plants could be expected to die.

Although large-leaved white clovers became more prostrate and smaller-leaved under intensive grazing, the adaptation is unlikely to be sufficient to prevent most photosynthetic tissue from being grazed by sheep. The small leaved varieties are presumably more tolerant of intensive sheep grazing because the shorter petioles keep a greater proportion of leaflets below the grazing horizon. Also, a more extensive network of branched stolons in the small leaved types would be expected to result in considerably more leaves per unit area (Davies & Evans, 1982) and possibly a greater contribution by stolons to photosynthesis (Davidson & Birch, 1972).

Rotational grazing systems which permit a period of clover canopy development and allow for the accumulation of reserves could be expected to improve clover persistence compared with an intensive continuous grazing system. Recent work in Northern Ireland (Laidlaw & McBratney, 1983) has shown that the adverse effect of high stocking rate on clover experienced in continuously grazed swards can be partially alleviated by rotational grazing. Further work is continuing at the Grassland Research Institute (U.K.) to investigate the relative merits of continuous versus rotational grazing on the production and persistence of white clover in mixed swards.

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