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The pasture ryegrass plant, what is it?

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Abstract

Detailed studies of plant growth processes are important in understanding the performance and persistence of species in pastures, particularly in response to uncharacteristic environmental stress. The morphology of perennial ryegrass plants in mixed sheep grazed pastures was determined in self contained farmlets under contrasting managements of rotational grazing, set stocking or a combination of both. Average size was 90 mg total DW, with 4-5 tillers and 12-13 leaves, little different to white clover. Ryegrass exhibits strong clonal growth, with extension at the apex and death of the basal stem releasing branches to form new plants at regular intervals, maintaining a stable population structure of small plants all year. The normally short internodes on ryegrass stems can elongate to form stolon and elevate the apex to a more favourable position if survival is threatened. On average only 2530% of plants contained stolon at any one time. Because of high plant density the quantities of ryegrass stem present was often in excess of that produced by white clover in the same swards. Grazing management did not affect plant structure (numbers of tillers, leaves etc) only their size (dry weight), but had marked effects on pasture structure and subsequent survival of plants under stress.

Keywords perennial ryegrass, plant morphology, grazing management, seasonal variation, plant survival, stolon formation

Plant loss and pasture stability

Perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) form the basis of most general purpose, grazed pastures sown in New Zealand (Harris 1968; Belgrave et *al.* 1990). Each seed sown represents an individual genotype, contributing to the genetic diversity of the population. Losses of plants (genotypes) during establishment while individuals can still be identified are known to be high, estimates ranging from 50 to 90% in the first year. Once pasture density increases and plant identity is lost, studies of further losses become difficult. McNeilly & Roose (1984), using the *isoenzyme* technique estimated the number of genotypes of perennial ryegrass in a 10-year-old pasture to be approximately 160/m², and in a 40-year-old pasture to be only 20/m². Trathan (1983) estimated white clover genotype density in an established pasture in Wales at 45-50/m². Considering that a sowing rate of 15 kg/ha of ryegrass and 3 kg/ha of white clover equates to 1000 and 400 seed (genotypes)/m² respectively, the loss in genetic diversity is considerable.

Investigation of individual plant growth processes should help identify some of the causes of loss in established pastures. Such studies on white clover have identified the mid-spring decline in plant size, when old stolon dies and large plants break up into numerous small plants (Brock et *al.* 1988; Hay et *al.* 1983, 1988), as making the population susceptible to stress during the following recovery period. Drought through this period (late spring-early summer) although uncommon, can be devastating. Hoglund (1985) reported a 75% loss of white clover production in 2 successive years from spring droughts at Lincoln, and Brock (1988) found a 95% loss in white clover plants and productivity from a spring drought in Palmerston North. In the latter, grazing management had a major influence in modifying the effects of the drought on survival, not directly on the white clover itself, but indirectly through the companion ryegrass. The high ryegrass tiller density induced by set stocking maintained pasture cover, protecting the white clover stolons from direct radiation and maintaining lower soil surface temperatures. In the open low density rotationally grazed pastures there was little protection afforded by the ryegrass and the white clover withered and died. Similar studies on ryegrass plants, the major component of pastures, would be of benefit to understanding stability, amelioration of environmental stress and loss of genetic diversity in established pastures.

The experimental pastures, their management and measurement

The pastures were part of a larger, long term, farmlet scale experiment investigating the interaction of grazing management and pasture species. Sown in autumn 1984 to perennial ryegrass (36 kg/ha) and white clover (3 kg/ha) and established under frequent, light, on-off grazing for 1 year, the pastures were then incorporated into grazing management systems of 1) rotationally grazed (R) all year, 2) set stocked (S) all year, and 3) set stocked lambing to weaning (Aug-Dec) then rotationally grazed (RS). Stocking rate was *22.5* ee/ha.

In winter 1988, by which time the pasture structure was judged to be in balance with the management system, measurements of sward structure and plant morphology began andcontinueduntil December 1989. At 2-monthly intervals, 2 turves 300 x 300 mm were removed by steel-edged quadrat and spade, washed free of soil and intactplants removed. In the laboratory these were dissected into stolon and tillers, leaf and tiller numbers and stolon length recorded, then dry weight (DW) determined. At each sampling 80, 50 mm diameter pasture cores were removed to estimate ryegrass tiller and white clover growing point density and dispersion pattern, and pasture shoot biomass.

Ryegrass plant growth form

In most mixed pastures erect tufted species (phalanx growth form) such as grasses generally dominate, with prostrate stoloniferous species in a secondary role colonising the remaining available space. Perennial ryegrass and white clover are good examples of each type. Both exhibit strong clonal growth with growth at the stem (stolon) apex, forming nodes bearing one leaf plus root and branchmeristems separated by internodes. Death of older basal stem releases branches to form new plants (Figure 1). In white clover the internode is elongated horizontally to exploit the space available, whereas inryegrass with thestolonapexmaintainednear the soil surface, the internode is kept short, resulting in a dense tuftof short erectcompact branches. Occasionally some internodes do elongate to form stolons, but their significance had beenlargely overlooked. Recent research has shown it can occur with great frequency and may be a major agent in plant spread (Harris *et al.* 1979; Korte & Harris 1987; Matthew *etal. 1989). Thus* the stem can be differentiated into two forms:

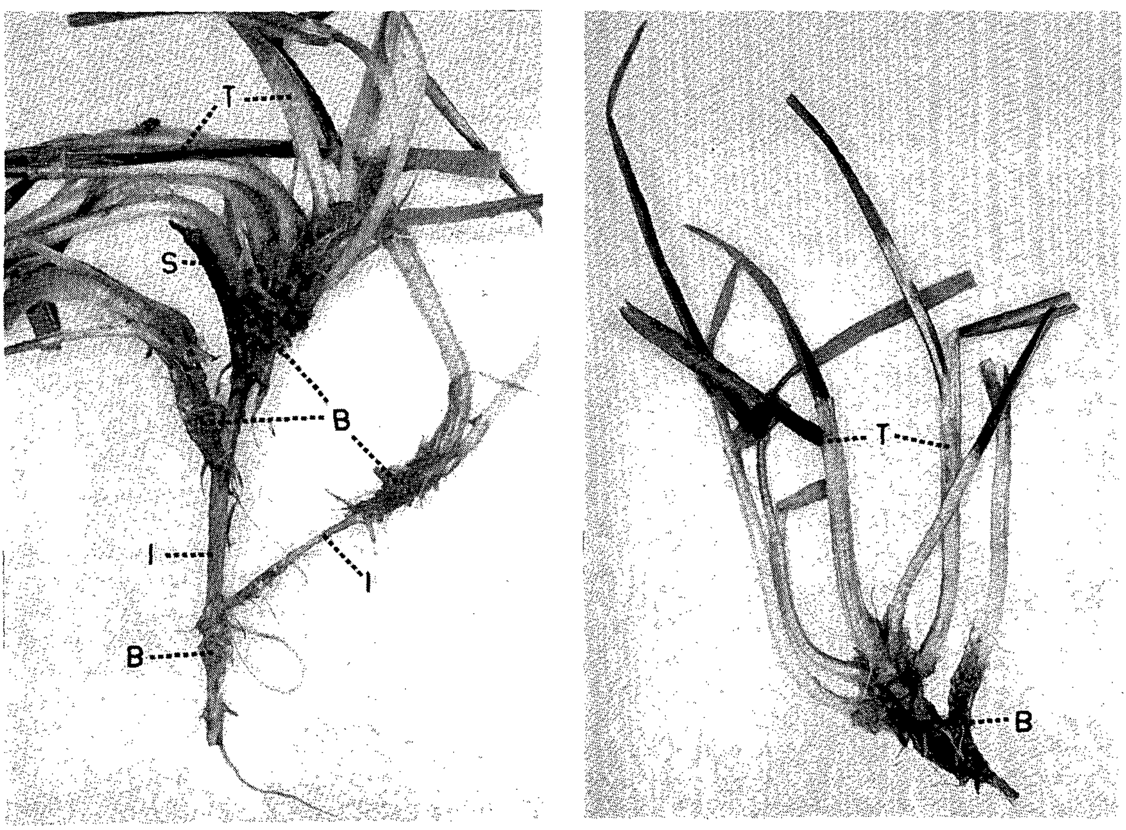

Figure 1 Morphology of shoots of perennial ryegrass plants. B basal stem. vegetative growth. I = elongated internode stolon, vegetative growth. S = elongated flowering stem. reproductive growth. T = tillers. (x 1.75 approx.)

Table 1 Effect of pasture management on the mean characteristics of perennial ryegrass plants (and white clover for comparison in parentheses. Brock et 01. 1988).

Character	Rotational grazing			Set stocked		R/S		Mean	
Leaf DW (mg)	76	(64)	•	36	(26)	68	(36)	61	(43)
Stem DW (mg)	23	(76)		20	(35)	29	(45)	24	(52)
Total DW (mg)	106	(140)	•	60	(61)	102	(63)	69	(95)
Leaf:stem ratio	4.5	(0.97)	•	2.7	(0.76)	3.3	(0.69)	3.5	(0.67)
Basal stem length (mm)	16	(166)	•	21	(91)	23	(105)	21	(121)
% with I stolon	26		.	40		44		37	
I stolon length (mm)	21			16		24		21	
Leaf number	12.5	(8.9)		11.5	(7.6)	13.1	(9.1)	12.4	(8.6)
Tiller number	4.7	(5.0)		4.4	(5.1)	5.0	(5.0)	4.7	

• Rotational and set stocked significantly different (P<0.05).

1. Basal stem (B), subtending all independent tillers, consisting of nodes separated by short internodes.
2. Internode stolon (I) formed occasionally when intercalary meristemic activity elongates the internode (Barnard 1964). These can be formed a) all year round, orb) in association with flowering in late spring-early summer.

On average, ryegrass plants are small (Table 1), similar in size to white clover. Being an erect tufted species the majority of stem is of the short compact B type with a much larger proportion of its growth directed towards leaf production (DW and number). With the constant death and decay of old basal stem causing the regular break up of plants, large clumps of ryegrass that develop are in reality dense populations of small independent plants. Many are only single tillers (Table 2), with more than 60% having fewer than 5 tillers (mean size). Only 15% had more than 7 tillers (maximum 43), generally consisting of several interconnected groups of branches, each of about 4-5 tillers (often less). On a tiller population basis those large plants form a greater proportion.

Table 2 **The percentage distribution of a) plants, and b) tillers of the ryegrass population among plant size classes based on number of tillers per plant.**

Population		Tillers/plant					
		1	2	3	4	5-7	8+
(a)	Plant	14	17	17	14	22	16
(b)	Tiller	3	6	12	11	30	36

Normally the apex of ryegrass tillers is at or just below the surrounding ground level, where there is sufficient light reaching the tiller bases to maintain new tiller formation and growth. Increasing the shading of tiller bases resulted in reduced tillering (Mitchell & Coles 1955). This can occur either through physical soil burial by wormcasting and stock treading, or through submergence of older or weaker tillers within the developing clump by stronger growing tillers or plants. In either case this may stimulate the formation of I stolon to elevate the apex to a more favourable position as a survival mechanism, as only a proportion of the plants possess I stolon at any one time.

Seasonal pattern of plant growth

There was less seasonal variation in ryegrass plant size (DW) and structure (tiller numbers) than in white clover (Figure 2). While the pattern of DW change was similar to white clover there was less variation particularly in spring. Larger size over November-January was associated with flowering. Basal stem length remained static all year showing growth at the apex and death at the base were in balance, releasing new plants from branches in a regular pattern.

The seasonal pattern of ryegrass tillering is an increase during spring both before and after flowering, but during flowering losses can be high (Hunt & Mortimer 1982). With little change in tillers per plant, plant density must parallel changes in tiller density, indicating that plant break up is directly related to tiller formation. This is in marked contrast to white clover, which shows a loss of plant size and structure in mid-spring as death rates of old stolon exceed the rate of new stolon formation (Brock *et al.* 1988).

In this experiment no differentiation was made between I stolon associated with reproductive (flowering stem) and vegetative (clonal) growth of plants. Allowing for an increase in I stolon during flowering (Nov-Dec), the proportion of plants with I stolons concerned with clonal spread (25-30%) and the length of I stolon/plant (15-20 mm) remain relatively constant throughout the year. This suggests that the stimulus to elevate the stolon apex may be related to other factors besides seasonal burial by wormcasting and treading.

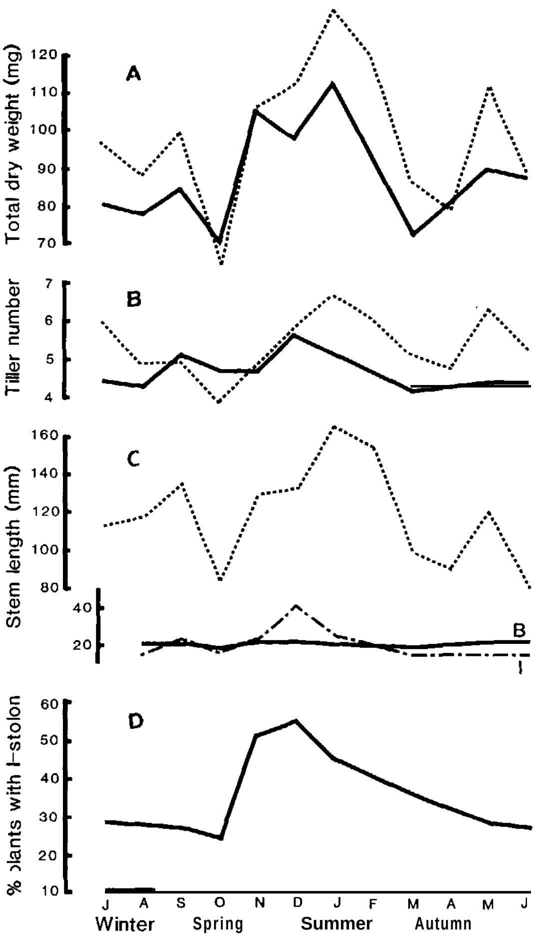

Figure 2 **Seasonal variation in the size and structure of perennial ryegrass plants, a) total dry weight, b) tiller numbers, c) stem length (B = Basal stem. I = internode stolon), d) proportion of plants with I stolon. (Compared with white clover, dashed line).**

Grazing management

As found in white clover, grazing management had little effect on the structure of the ryegrass plants (leaf and tiller numbers), but large effects on the size of plant organs (Table 1). Leaf DW of Rplants was twicethat of S plants, but differences in stolon were less marked, being only 20% heavier. Basal stem was 20% shorter in R plants than in S plants. I stolon length was similar for all managements, but considerably more plants formed I stolons under set stocking (S and RS) than under rotational grazing.

These differences are a result of contrasting defoliation pattern between the management systems, e.g. infrequent (24-48+ days' regrowth), severe (80+% utilisation of leaf) defoliation under rotational grazing, compared with frequent (6-12 days between defoliations), lenient (50% leaf utiliiation) under set stocking (Curll & Wilkins 1982). This resulted in rotationally grazed pastures that had: greater expression of leaf growth; lower tiller density; lower residual pasture with reduced base shading of tillers and slower clump development, than set stocked pasture. As a consequence the necessity for R plants to extend using B stem or rapidly elevate the stolon apex using I stolon for survival would be reduced.

By combining tillers per plant and pasture density data, the number of plants and the quantities of ryegrass stolon in pastures can be estimated. Because of its dominance in the pasture and high plant density, the yield andlengthofryegrass basalstemwereconsiderable, being greater than white clover in weight and similar in length, except under rotational grazing. Quantities of I stolons produced were less than those found in the associated white clover. These values were also less than those reported by Korte & Harris (1987) and Matthew *et* al. (1989), which may be a reflection of difference in pasture age or genetic differences in seed line sown, as Harris et *al.* (1979) found that genotypes varied in their ability to form I stolon.

Both Korte & Harris (1987) and Matthew *et* al. (1989) suggested that under rotational grazing, lax grazing to high residual yield (>2000 kg/ha) promoted I stolon formation. The high stocking rate of the self contained farmlets of this study did not allow such high residual yield to occur (Table 3) and length of I stolon/plant was the same for all systems. Nevertheless more plants formed I stolon under set stocking, which could be a reflection of lower stress (lenient defoliation) on plants (as well as increased density suggested above), as also suggested by Brock *et* al. (1981) on the basis of N fixation modelling of these systems.

Table 3 Mean annual pasture structure, plant density and stolon quantity of perennial ryegrass in grazed wards (compared with white clover where possible. in parentheses).

	Rotational grazing		Set stocked		R + S	
Tillers/m²	6460	(2900)	12460	(4400)	11130	(3290)
Area of low density (%) (<5000/m²)	46		23		30	
Residual yield (kg/ha)	600		1045		1010	
Plants/m²	1690	(580)	3360	(660)	2330	(660)
Stolons/m²	600		1660		1230	
Basal stem DW (g/m²)	36		53		54	
I stolon DW (g/m*)	6		12		15	
Total	44	(44)	66	(30)	68	(30)
Basal stem length (m/m²)	34		70		54	
I stolon length (m/m²)	10		24		24	
Total	44	(96)	94	(76)	79	(69)

Implications for sustained stability and productivity

Clearly the observation of large 'plants' of some hundreds of tillers occurring in pastures is erroneous. Such clumps will consist of many small independent plants, not necessarily of one genotype as adjacent clumps could merge through I stolon formation. Conceivably, weaker genotypes could be crowded out by clumps of stronger genotypes should conditions allow it, a possible cause for the gradual loss of genetic diversity in old pastures observed by McNeilly & Roose (1984).

The role of the ryegrass clump may be of importance. The high density of set stocked pastures as a result of reduced tiller loss (Hunt 1989) and expansion of clumps to form a more even density pasture, affords a high degree of plant protection in adverse conditions such as drought (Brock 1988). Although clump expansion is reduced by rotational grazing and plant death was high during drought, most larger ryegrass clumps had some surviving plants within it, whereas smaller clumps or individual plants died. Recovery by such survivors was rapid. Such events, while not common, result in large loss of genetic diversity within the pasture.

Overall, it would appear that some period of set stocking would be an important management tool in widening stability and persistence of pasture. Hay & Baxter (1989) found that heavy set stocking during spring produced clover-dominant pastures once returned to rotational grazing in summer, useful for high quality lamb fattening feed. Colville & Marshall (1984) and Matthew *et* al. (1989) have shown that tillers appearing immediately after flowering in December were important in forming the main tiller base of the pasture. for the following year, and management to enhance their survival is important. Set stocking over this period, in reducing defoliation stress and tiller disappearance and providing protection from dry conditions, would appear to be best suited to maintaining a strong stable plant population for sustained productivity.

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