Proceedings of the New Zealand Grassland Association 45: 124-130 (1984)

OBSERVATIONS ON THE DISTRIBUTION OF WHITE CLOVER STOLONS IN HILL SWARDS

M.J.M.HAY and D.F.CHAPMAN
Grasslands Division, DSIR, Palmerston North.

Abstract

Hill swards under mob stocking by sheep at Taupo, Ballantrae and Wairarapa were sampled every three months for one year and white clover stolon dissected into three vertical classes: aerial, surface and buried. In 198081 swards at Ballantrae under three different grazing managements, rotationally grazed by cattle (RGC) and by sheep (RGS) and set stocked by sheep (SSS), were sampled six times over one year and white clover stolon dissected out.

The distribution of stolon among the three vertical classes varied with season. Buried stolon ranged from a minimum of 42% in autumn to a maximum of 86% in early spring. The proportion of stolon in the aerial and surface classes peaked in summer at 14% and 48% respectively and was at a minimum in early spring (1% and 13%). Distribution of stolon among the vertical classes differed among sites. The Taupo site had respectively 12% and 17% less stolon buried than the Ballantrae and Wairarapa sites. Environmental conditions such as overgrazing during drought reduced the amount of white clover stolon by up to 70% and modified distribution in favour of the buried class.

Grazing management had a large effect both on the amount of stolon in the swards and on the morphology of stolons. Under RGC there was greater total stolon weight (570 kg/ha) than under RGS (310 kg/ha) and SSS (225 kg/ha). Stolons under RGC were heavier per unit length by 32% and 53% respectively than the stolons under RGS and SSS managements.

Keywords: white clover, hill swards, stolons, grazing management, vertical distribution, stolon morphology.

INTRODUCTION

The seasonal pattern of distribution of stolons down the vertical profile of swards has been established on lowland pastures (Hay 1983, Hay et al 1983) and Fig. 1 presents the results in generalised form. A high proportion of stolon is buried, especially over winter-early spring. This buried stolon fraction is thought to play an important part in the regeneration of growing points on the soil surface in spring (Hay 1983).

In view of the local nature of previous studies and the importance of the role of white clover in increasing the productive capacity of hill country swards (Suckling 1976), white clover stolons at three hill country sites were examined to study the effects of season, and at one site the effect of grazing management on stolon mass and morphology was examined.

MATERIALS AND METHODS

Swards from three sites with sloping terrain (10-30°), easterly aspect and under rotational grazing or mob stocking by sheep were sampled at three monthly intervals from 28 September 1982 to 24 June 1983 by randomly taking 48 cores of 50 mm diameter to 50 mm depth. White clover in the cores was dissected into aerial, surface and buried classes (Hay 1983) and dry weights were obtained.

Table 1: MEAN RAINFALL (mm) AND ACTUAL RAINFALL AT EACH SITE FOR THE PERIOD OF STUDY.

		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
Wairarapa[1]	1961-79	124	117	94	60	48	75	56	42	71	80	108	116
	1982-83	114	43	39	52	34	41	14	22	49	61	122	68
Ballantrae	1970-82	116	107	111	110	87	105	74	70	100	86	114	105
	1982-83	107	66	78	87	76	161	68	51	65	111	131	110
Taupo[2]	1960-82	118	118	114	90	92	123	78	89	95	80	100	113
	1982-83	58	29	66	96	32	98	46	15	21	97	90	80

[1] Rawhiti homestead, collected by Mr D.Pocknall
[2] Wairakei Research Station (MAF)

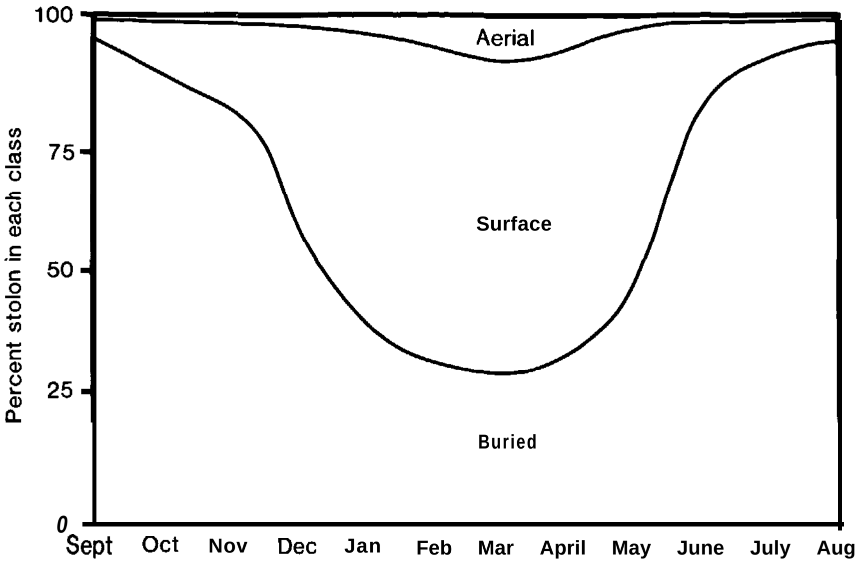

Figure 1: Seasonal variation in dry weight distribution among aerial surface and buried stolon classes as found in lowland pastures (Hay, 1983; Hay et al, 19831.

Site Descriptions

Taupo

The site is on the Aratiatia block of Lands and Survey, which is 5 km north of Taupo. Soil type is Taupo hill series and has a 100 mm soil horizon over pumice. Average rainfall (1960-82) recorded at Wairakei Research Station (5 km north) is 1221 mm and is distributed such that moisture deficits are common in summer and autumn. Rainfall from July to February was below average but distribution was such that dry conditions did not occur until February (Table 1). The pasture sampled was the control plots in an area which had been intensively mob stocked over winter (1982) to break up the 30 mm turf mat. The pasture received 300 kg/ha superphosphate and had an Olsen P test of 12 at March 1982. In September 1982 ryegrass, cocksfoot, sweet vernal, browntop and Yorkshire fog made up about 75% of the pasture and white clover content was about 7%.

Ballan trae

This site is on the hill country research area of Grasslands Division, DSIR, 20 km NE of Palmerston North. A rotationally grazed pasture receiving an average annual application of 630 kg/ha of superphosphate since 1975 (Lambert et al. 1983) was sampled. Olsen P values of soils receiving the above fertiliser rate averaged 14 in 1980 (Lambert et al. 1982). Average rainfall (1970-81) is 1276mm per annum and is usually evenly distributed throughout the year. Rainfall from July to November was drier than average while rainfall over summer (December-February) was above average because of high rainfall in December (Table 1). Soil type is Whetakura hill soil, a yellow brown earth. Pastures are dominated by ryegrass, browntop, sweet vernal and crested dogstail with approximately 10% legume on an annual basis (Lambert *et al. 1982).*

In addition to the 1982-83 sampling, 20 cores of 50 mm diameter were taken from the set stocked sheep (SSS), rotationally grazed sheep (RGS) and rotationally grazed cattle (RGC) pastures on six occasions from January 1980 to January 1981. All samples were taken from sites facing east and receiving the same fertiliser as above. White clover stolons were dissected out for determination of length and weight, but were not separated into vertical distribution categories.

Wairarapa

Rawhiti Station, 15 km east of Masterton was the site of this trial. Average annual rainfall (1961-79) is approximately 990 mm with pronounced summer droughts frequent. Rainfall was below average for the July-February period (Table 1). Pastures were mob stocked and were predominantly ryegrass (52% of annual DM production in 1982) with a moderate subterranean and white clover component. Soil type is Kourarau or Waimaram silt loam. Olsen P measured at a site near the area sampled averaged 3 in 1981.

RESULTS

Stolon Dry Weight

Mean stolon dry weight was greater ($P<0.01$) at Ballantrae than at Taupo and Wairarapa and season did not significantly affect mean stolon dry weight (Table 2). Stolon dry weight tended to vary more with season at Taupo and Wairarapa than at Ballantrae (Table 2).

Distribution of stolon dry weight among the aerial, surface and buried classes varied with season ($P<0.001$) (Table 3a) and among sites ($P<0.01$) (Table 3b). In autumn the distribution at Wairarapa (Table 3a) differed from that of the mean.

Table 2: DRY WEIGHT (kg/ha) OF STOLON AT EACH SITE IN EACH SEASON. (LSD 5% FOR EACH SET OF MEANS IN PARENTHESES).

	Spring	Summer	Autumn	Winter	Means (168)
Taupo	95	135	203	172	151
Ballantrae	429	421	562	446	465
Wairarapa	119	282	84	26	128
Means (145)	214	279	283	215	

Grazing Management Trial (Ballantrae)

The type of grazing management had significant effects on both the amount of stolon in swards ($P<0.001$) and on the weight per unit length of stolons ($P<0.001$). The RGC sward had 83% and 157% more stolon weight than the RGS and SSS swards respectively, and while the difference between RGS and SSS was not significant, the differences in weight per unit length among all managements were significant (Table 4). Weight per unit length of stolon varied with season ($P<0.05$).

Table 3: MEAN DISTRIBUTION OF STOLON (EXPRESSED AS PERCENTAGE OF TOTAL STOLON DRY WEIGHT) AMONG 3 VERTICAL CLASSES: a) IN EACH SEASON; AND b) AT EACH SITE.

		Aerial	Surface	Buried
a) Season	Spring	1	13	86
	Summer	14	27	59
	Autumn	10 (7)'	48 (27)	42 (66)
	Winter	1	21	78
	LSD 5%		11.9	
b) Site	Taupo	7	36	57
	Ballantrae	6	25	69
	Wairarapa	6	20	74
	LSD 5%		10.3	

[1] Wairarapa

Table 4: DRY WEIGHT AND WEIGHT PER UNIT LENGTH OF STOLONS FROM SWARDS AT BALLANTRAE UNDER ROTATIONAL GRAZING BY CATTLE (RGC) AND SHEEP (RGS) AND SET STOCKING BY SHEEP (SSS).

Sampling Date	Dry Weight (kg/ha)			Dry Weight/Unit Length (g/m)		
	RGC	RGS	SSS	RGC	RGS	SSS
January 1980	349	198	119	.37	.37	.25
April	528	415	169	.45	.39	.33
July	547	362	244	.58	.51	.40
Sept	717	383	309	.47	.36	.28
Nov	831	236	226	.55	.29	.30
January 1981	472	290	272	.49	.39	.38
Means	574	314	223	.49	.39	.32
LSD 5%		130			0.06	

DISCUSSION

The seasonal shift in distribution of stolon among the aerial, surface and buried classes (Table 3a) followed the pattern summarised in Figure 1 for lowland pastures. There was a shift from 85% of total stolon buried in spring through to about

40% buried in autumn. By June, as a result of stock treading and wormcasting (Hay 1983) over autumn, distribution among the classes was tending towards that of spring. However results obtained in this study show that site factors affect the vertical distribution of stolons as the Taupo site had significantly more surface and less buried stolon than the other two sites (Table 3b) and the autumn distribution at Wairarapa differed from that of the other two sites in response to conditions at that site. Hence the general seasonal pattern of change in the vertical distribution of stolons (Fig, 1) can be strongly modified by conditions specific to a site.

Very low worm populations at the Taupo site ($3\cdot6/m^2$) (J.Lancashire *pers comm.)* may be a factor acting to reduce the proportion of stolon that is buried at this site. Worm populations at Ballantrae ($1\ 260/m^2$) and Wairarapa ($680/m^2$) are considerably greater and may mean that burial by wormcasting is a more important factor at these sites.

Drought conditions influence pasture management in that as a result of restric--ted pasture growth and continued stock grazing, herbage mass decreases. As it does, removal of white clover stolon by grazing sheep increases (Lancashire & Keogh 1968; Curll & Wilkins 1982) and so stolon mass is further reduced over and above the losses in mass owing to death from moisture stress. At Wairarapa over summer, total stolon mass decreased sharply and after increased defoliation of stolon by sheep the proportions of surface and aerial stolon decreased and that of buried stolon increased compared with stolon in swards at Ballantrae and Taupo (Table 3a). Further evidence of the grazing pressure on the sward at Wairarapa was the low harvest index (ratio of leaf weight to stolon plus leaf weight) of 0.16 compared with 0.26 and 0.29 at Ballantrae and Taupo respectively. White clover stolon mass in late autumn-early winter at the Wairarapa site (Table 2) continued to decline after the drought had broken. A possible explanation for this result could be that the autumn measurement over-estimated the quantity of live stolon by including dry, dead undecomposed stolon in the sample, as it was very difficult to distinguish between live and dead stolon in the dry conditions of that sampling. A high count of white clover seedlings ($31.8/m^2$) in the sward (Chapman unpub.) indicates that regeneration from seed might be an important mechanism of replenishment in this environment. Thus white clover may recover more rapidly than would be expected from the stolon mass levels in winter.

The large difference in stolon mass between Ballantrae and the Taupo and Wairarapa sites reflects the more favourable summer rainfall (Table 1) and the high phosphate status of the Ballantrae soils. The large influence of summer rainfall on total stolon mass is clearly demonstrated. While moisture was non-limiting in spring, stolon mass increased (except at Ballantrae which remained constant at a high mass) at all sites up to the summer sampling with the greatest increase occurring at the Wairarapa site. However low rainfall here (251 mm September-March, 586 mm at Ballantrae) lead to drought conditions and resulted in a 70% decrease in stolon mass by autumn (Table 2). However the Ballantrae and Taupo sites had more favourable summer rainfall and stolon mass increased up to the autumn sampling. Whilst summer rainfall was the prime influence on stolon mass, the high soil phosphate status at Ballantrae probably allowed greater expression of growth potential of clover by removing limitations to growth imposed by grass competition for phosphate (Jackman & Mouat 1972). This probably accounts for the high mass that is sustained at Ballantrae.

The effect of grazing management both on the amount of stolon and mor-

Table 1: DESCRIPTION OF SITES AND THEIR MANAGEMENT

Site	Soil	Fertiliser	Grazing Management and Pressure (GP)[1]
WET 1 Makuri	Pukeokahu steepland	200 kg/ha superphosphate 1979; 0.5 t/ha lime 1980	Ewes & Lambs set-stocked (SS) all year, extra mobs regularly; GP 1 - varying all year.
WET 2 Coonoor	Waimarama hill soil	200 kg/ha superphosphate annually	Ewes & Lambs SS October-May, rotationally grazed (RG) May-September. Cattle SS all year, 0.5-1/ha; GP 4 - heavy winter, light in summer.
DRY 1 Weber	Tinui Hill (shallow)	200 kg/ha superphosphate annually, except 1981	Ewes & Lambs SS September-December, RG autumn, light grazed summer, winter. Cattle occasionally; GP 3.
DRY 2 Horoeka	Tinui Hill (deeper)	200 kg/ha superphosphate annually, except 1982	Ewes & Lambs SS winter-early spring, RG otherwise; Cattle winter & spring; GP 4 -heavy all year.
MOIST 1 Ballantrae	Mangamahu steepland	130 kg/ha superphosphate annually since 1977	Ewes & Lambs SS all year; GP 5 - heavy all year.
MOIST 2 Aokautere	Raumai hill	200-300 kg/ha superphosphate annually - none 1982, 83	Ewes & Lambs SS August-December, RG January-August; GP 2 - light winter, heavier in summer

[1] Grazing pressure ranked on a O-5 scale with 5 heaviest (pasture closely grazed)

phology of stolons was large (Table 4). This result is in general agreement with Hay (1983) and Hay et *al. (1983)* in that grazing by cattle gave greater stolon mass and stolon diameter than grazing by sheep and the system of grazing of sheep affected weight per unit length rather than stolon mass. Thicker, heavier stolons produce larger leaves on thick petioles (Chapman 1983) which are more readily utilised (Wilman & Asiegbu 1982) than the smaller leaves produced from thin stolons. Lambert et *al.* (in prep.) found that under RGC management the white clover population had a higher ratio of Huia to resident clover than under RGS and SSS managements. Thus the genetic base of the clover population differed among managements. As Huia has greater potential to exploit the more favourable growth conditions (lower sward density and defoliation to a higher above ground level) under RGC (Lambert et *al* in prep.) the genetic differences in the clover populations under different management may contribute to the large differences observed.

ACKNOWLEDGEMENTS

The authors are grateful to Mr J.A. Lancashire and Mr D.J. Barker for access to their trials and site information and Grasslands staff at Ballantrae for management of the pasture sampled. Mr M.R. Robertson is thanked for assistance given at sampling and in manuscript preparation. Mr R.H. Fletcher, Applied Mathematics Division, DSIR, Palmerston North is thanked for advice on statistical procedures,

REFERENCES

Chapman, D.F. *1983: Jl Appl. Ecol. 20:* 597-608

Curll, M.L.; Wilkins, R.J. *1982: Grass and For. Sci. 37:* 291-297

Hay, M.J.M. 1983: *N.Z. J. agric. Res. 26: 29-34*

———; Brock, J.L.; Fletcher, R.H. 1983: *N.Z Jl exp. Agric. 11:* 215-218

Jackman, R.H.; Mouat, M.C.H. *1972: N.Z. Jlagric. Res. 15: 653-666*

Lambert, M.G.; Luscombe, P.C.; Clark, D.A. *1982: Proc. N.Z. Grassld Ass. 43: 153-160*

———; Clark, D.A.; Grant, D.A.; Costall, D.A. 1983: *N.Z. Jlagric. Res. 26:* 95- *108*

Lancashire, J.A.; Keogh, R.G. 1968: Sheepfarming Annual: 29-35

Suckling, F.E.T. 1976: *In* 'Hill Lands', Proceedings International symposium. West Virginia University, West Virginia, U.S.A. 367-381

Wilman, D.; Asiegbu, J.E. 1982: *Grass and For. Sci. 37: 15-27*