HERBAGE PRODUCTION OF PASTURE LEGUMES AT THREE SITES IN OTAGO

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Abstract

White clover *(Trifolium repens)*, red clover *(T. pratense)*, subterrnnean clover *(T. subterraneum)* and alsike clover *(T. hybridum)* were sown singly or in combinations at three sites in Otago. Ryegrass *(Lolium perenne)* was included in all clover treatments and was also sown alone. Lucerne *(Medicago sativa)* was sown alone at two sites. Herbage dry matter production was measured over a three-year period. At the high fertility lnvermay site, white and red clovers gave similar total and legume dry matter production and were markedly superior to alsike and subterranean clovers. White and alsike clovers were most productive at the higher altitude, low fertility Berwick site, and at the dry, medium fertility Dunback site red clover produced the highest yields. Lucerne greatly outyielded all other species in the second and third years at Invermay and in the third year at Dunback.

INTRODUCTION

A WIDE RANGE of environments exists throughout Otago, including the dry foothill country in North Otago, the infertile acid soils of higher altitude tussock grasslands and the high-fertility alluvial soil of the Taieri Plain.

Although the use of legumes in improved pasture is universal in Otago, little documented evidence is available on legume production, either alone or in grass mixtures.

Trials carried out by McLeod (1968) to determine the production of pasture species in South Canterbury showed that Montgomery red clover was high yielding. Clifford (1973) showed alsike clover to produce well in the MacKenzie Basin, and Harris *et* al. (1973) demonstrated the value of white clover/ryegrass pasture in Southland.

Lucerne alone and lucerne/grass mixtures were evaluated as hay crops at Invermay, on the Taieri Plain, by Cullen (1965). The results suggested the importance of lucerne as an alternative to pasture in this area.

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The purpose of this investigation was to compare the herbage production of various pasture legumes and ryegrass in different environments in Otago, and to evaluate the use of lucerne as a hay crop in place of pasture.

EXPERIMENTAL

The trials were laid down in February 1970 on three sites. Invermay, near Mosgiel on the Taieri Plain, was chosen to represent a high-fertility site with adequate rainfall. Dunback, on rolling North Otago downlands near Palmerston, is a moderately fertile dryland site, and Berwick, 20 km inland in South Otago, is a higher altitude, low-fertility site in tussock grasslands with adequate rainfall. Site details are given in Table 1.

TABLE 1: DESCRIPTION OF SITES

	Invermay	*Dunback*	*Berwick*
Soil type*	Wingatui	Claremont	Waipori
Initial pH	5.G	*5.0*	*4.8*
P (Truog) (ppm)	*63*	*23*	*6*
Altitude (m)	*25*	*150*	*550*
Mean rainfall (mm)	*680*	*560*	*870*
Previous history.			
1967	Swedes	Browntop/ sweet vernal	Unimproved fescue tussock
1968	Fodder maize	Turnips	Ploughed
1969	Fallow	Turnips	Fallow

*N.Z. Soil Bureau (1968).

A randomized block layout with four replicates was used, with plot size 6 X 1.5 m. Treatment details are shown in Table 2. All treatments except lucerne were sown with basal ryegrass, 5.6 kg/ha at Invermay and Dunback, and 11.2 kg/ha at Berwick. Higher sowing rates were used at Berwick to ensure satisfactory establishment under the harsher environmental conditions. All legumes were inoculated at 20 times the recommended rate.

Each site received 350 kg/ha of molybdic superphosphate at sowing, and maintenance dressings of 350 kg/ha of superphosphate and 250 kg/ha of potassium chloride annually. Lime was applied at rates of 1 250 kg/ha at Invermay, 2 500 kg/ha at Dunback, and 5 000 kg/ha at Berwick, bringing the pH of each site up to 5.8, 5.9 and 5.4, respectively.

TABLE 2: TREATMENTS AND SOWING RATES

Treatment	Sowing Rate (kg/ha) Invermay & Dunback	Berwick
1. *Trifolium repens* L. 'Grasslands Huia' white clover	3.4	4.5
2. *T. pratense* L. 'Grasslands Turoa' red clover	5.6	6.7
3. T. subterraneum 'Woogenellup' subterranean clover	11.2	13.4
4. *T. hybridum* L. Alsike clover	3.4	4.5
5. Huia + Turoa	1.7 + 2.8	2.2 + 3.4
6. Huia + Woogenellup	1.7 + 5.6	2.2 + 6.8
7. Turoa + Woogenellup	2.8 + 5.6	3.4 + 6.8
8. Huia + Turoa + Woogenellup	1.1 + 2.0 + 3.8	1.5 + 2.2 + 4.4
9. *Lolium perenne* L. 'Grasslands Ruanui' perennial ryegrass	5.6	11.2
10. Wairau lucerne	11.2	—

Establishment counts were taken a month after sowing, using 12 random placements of a 232 cm' quadrat per plot. Lucerne plots were sprayed with 2,2-DPA (dalapon) nine months after sowing to control grass weed invasion. Clover treatments and ryegrass were cut to 3 cm when the herbage reached a height of 12 to 15 cm, while the lucerne was harvested when approximately 50 cm tall. Clover and ryegrass treatments were cut 8 to 9 times annually at Invermay, 4 to 6 times at Dunback and 3 to 4 times at Berwick. Lucerne was cut 4 to 5 times annually at Invermay and 0 to 5 times at Dunback. Clippings were not returned to the plots. Herbage samples were dissected into legumes, ryegrass, and other species.

RESULTS

ESTABLISHMENT

Establishment was satisfactory at each site, as indicated in Table 3.

DRY MATTER PRODUCTION

Invermay

Results are given in Tables 4 and 5, and Fig. 1. Lucerne was not included in the statistical analysis.

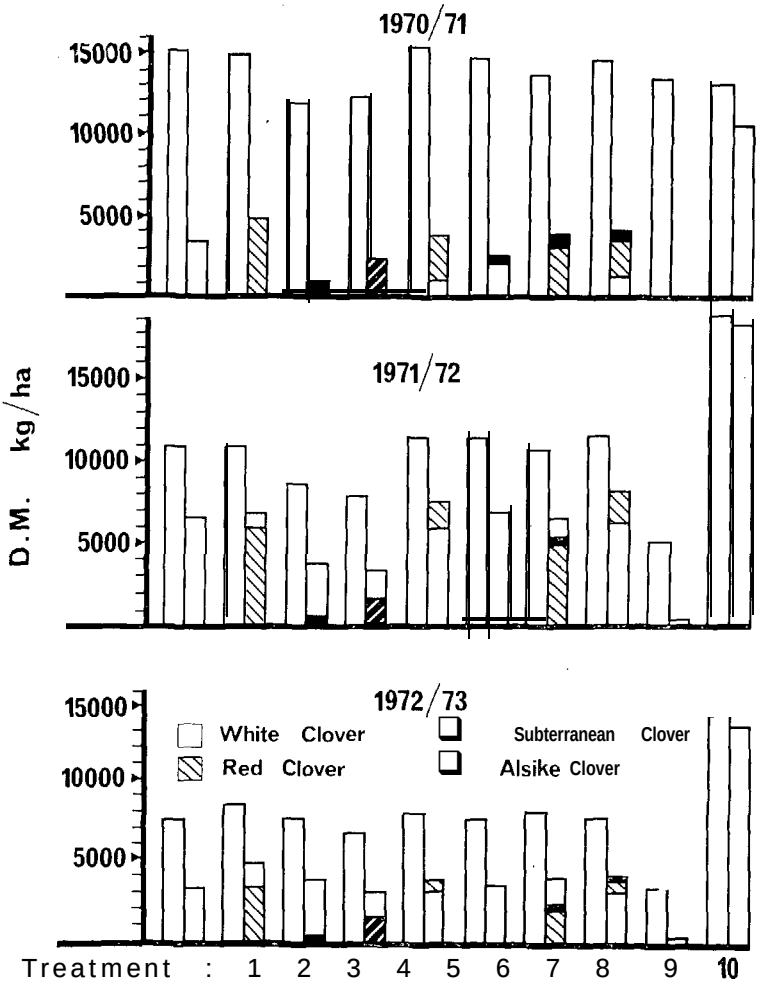

FIG. 1: Dry matter production, Invermay. (In Figs. 1, 2 and 3 the left-hand column of each pair represents total DM production, and the right-hand column shows the legume components of DM production.)

Total Dry Matter Yields

Total dry matter yields were high in the first year, but, with the exception of lucerne, declined in the second and third years.

Production of most clover treatments was similar, but the alsike clover and subterranean clover alone treatments produced significantly less ($P<0.05$) total dry matter than most other treatments

TABLE 3: ESTABLISHMENT, PLANTS/me

Treatment	Site		
	Invermay	*Dunback*	*Berwick*
1. White clover	258	215	280
2. Red clover	97	75	97
3. Sub. clover	43	54	54
4. Alsike clover	194	129	215
5. White clover	140	151	194
Red clover	54	54	54
6. White clover	151	129	183
Sub. clover	27	32	27
7. Red clover	43	43	48
Sub. clover	25	32	32
8. White clover	108	108	129
Red clover	43	32	32
Sub. clover	22	22	32
9. Ryegrass	172	205	312
10. Lucerne	226	258	—

TABLE 4: TOTAL HERBAGE DRY MATTER PRODUCTION kg/ha, INVERMAY

Treatment	*1970-l*	*1971-2*	*1972-3*	*Total*
1. White clover	15000 aA	10930 aA	7510bA	33440 aA
2. Red clover	14850 aA	10940 aA	8 370 aA	34 160 aA
3. Sub. *clover*	11 830 cc	8650 bB	7 520 bA	28000 bB
4. Alsike clover	12 100 bcBC	7810 bB	6 650 cB	26 560 bB
5. White + Red	15200 aA	11 350 aA	7 830 abA	34 380 aA
6. White + Sub.	14 500 aAB	11 460 aA	7 570 bA	33 530 aA
7. Red + Sub.	13 730 abABC	10 720 aA	7 920 abA	32 370 aA
8. White + Red + Sub.	14 490 aAB	11 670 aA	7 650 bA	33 810 aA
9. Ryegrass	13 310 abcABC	3 190 cc	3 310 dC	19 810 cC
10. Lucerne	12 990	18 970	14 010	45 970
CV%	8.4	4.5	5.7	5.7

In Tables 4, 6 and 8, figures within columns not followed by a common letter differ significantly at the 5% (lower case) or 1% (upper case) level of significance. Lucerne is not included in the analysis.

in the first year, and less ($P<0.01$) than all other clover treatments in the second year. The alsike clover remained low in the third year.

The ryegrass alone treatment gave significantly smaller ($P<0.01$) yields than all other treatments in the second and third years.

Lucerne production markedly exceeded that of other treatments in the second and third years, outyielding the. best clover treatments by 63% and 67%, respectively.

Total production differences between most treatments were small over the three-year period. The alsike clover and subterranean clover alone treatments yielded significantly less ($P<0.01$) total dry matter than any other clover treatments, while the ryegrass alone yielded less ($P<0.01$) than any other treatment. Lucerne exceeded the best clover treatment by 34%.

Seasonal *and* Compositional *Production*

Maximum dry matter production of white, red and alsike clovers occurred in summer, with a marked drop in autumn (Table 5). Red and white clovers had similar spring and autumn production where they were sown alone, but red produced 26% more dry matter than white clover alone in summer. Production of alsike clover and subterranean clover sown alone was low throughout.

Ryegrass contributed the bulk of spring and autumn production in each clover treatment, but clover equalled or exceeded ryegrass production in summer except in the subterranean clover alone treatment.

White clover was the dominant legume in mixtures, producing twice the dry matter of red and far exceeding the yield of subterranean clover.

Ryegrass was dominant in clover treatments in the first year (Fig. 1) , and clover dominated in the second. Volunteer clover, composed of white and some suckling clover *(T. dubium),* formed a substantial proportion of the legume yield of many treatments. During the course of the trial white clover almost completely eliminated subterranean clover, and by the third year formed a substantial proportion of the legume content of the red clover alone treatment.

Dunback

Results are given in Tables 6 and 7, and Fig. 2. Lucerne was not included in the statistical analysis.

TABLE 5: SEASONAL AND ANNUAL SPECIES HERBAGE DRY MATTER PRODUCTION (3-YEAR MEANS) kg/ha, INVERMAY

Treatment	Species	Spring	Summer	Autumn	Total Sown	Volunteer Legume
1	White clover	1280	2 390	580	4 250	160
	Ryegrass	4 210	1160	930	6 300	
2	Red clover	1 120	3 010	560	4 690	810
	Ryegrass	3 770	930	720	5 420	
3	Sub. clover	350	60	50	460	2 360
	Ryegrass	3 790	1 290	900	5 980	
4	Alsike clover	630	1010	130	1 770	1 120
	Ryegrass	3 680	990	730	5 400	
5	White clover	1 280	1 750	380	3 410	
	Red clover	310	1 100	190	1 600	30
	Ryegrass	3 860	1210	860	5 930	
6	White clover	1 330	2 230	590	4 150	
	Sub. clover	100	0	0	100	0
	Ryegrass	4 060	1 380	950	6 390	
7	Red clover	650	2 300	380	3 330	
	Sub. clover	260	130	50	440	960
	Ryegrass	4 080	900	740	5 720	
8	White clover	1 350	1 740	380	3 470	
	Red clover	210	1310	190	1710	0
	Sub. clover	150	40	30	220	
	Ryegrass	3 770	710	860	5 340	
9	Ryegrass	3 760	1660	1090	6 510	150
10	Lucerne	5 520	6 000	2 490	1410	0

TABLE 6: TOTAL HERBAGE DRY MATTER PRODUCTION kg/ha, DUNBACK

Treatment	1970-I	1971-2	1972-3	Total
1. White clover	6 050	6830 aAB	3 290 deD	16 170 deBC
2. Red clover	6 020	7 500 aA	6 180 aA	19700 aA
3. Sub. clover	5 560	5 090 c c	4400 c c	15 050 efC
4. Alsike clover	5 860	5 890 bBC	3 100 eD	14 850 fC
5. White + Red	5 880	1350 aA	4430 c c	17 660 bcB
6. White + Sub.	5 900	6930 aA	3 640 dD	16 470 cdBC
7. Red + Sub.	5 550	6780 aAB	5 580 bB	17 910 bB
8. White + Red + Sub.	5 790	7 230 aA	4 600 cC	17 620 bcB
9. Ryegrass	5 660	2 890 dD	1 330 fE	9 880 gD
10. Lucerne	—	7 740	8 820	16 560
CV%		7.6	7.1	5.2

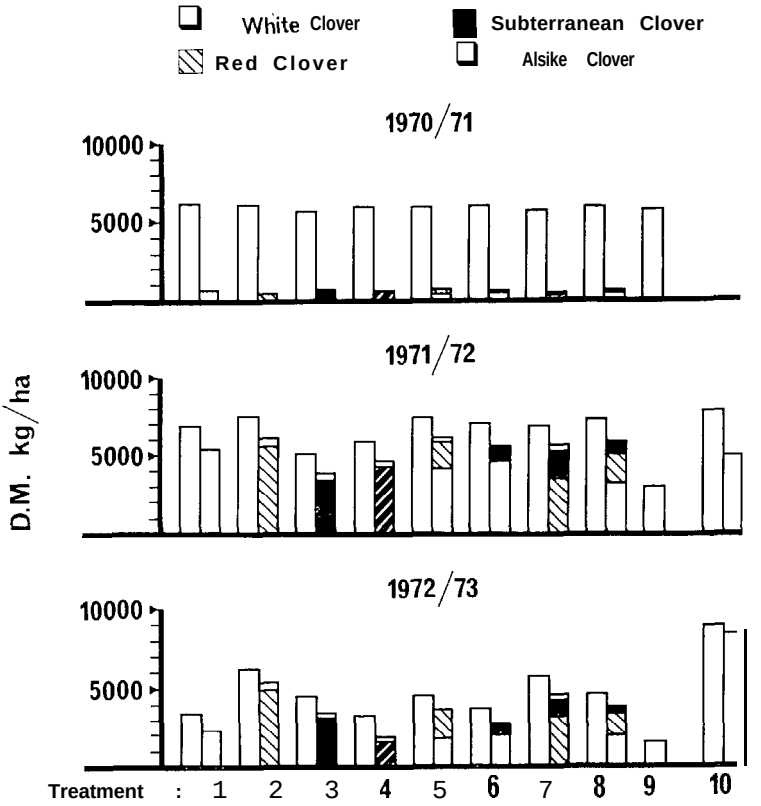

FIG. 2: Dry matter production, Dunback.

Total Dry Matter Yields

Yields of the clover and ryegrass treatments were similar in the first year, but the lucerne was not harvested as little growth had occurred. The yield data from the first year were not statistically analysed.

Although autumn production in the second year was removed by an accidental grazing, yields were similar to or exceeded those of the previous year. In the third year, however, yields of most treatments dropped markedly, and differences between treatments increased.

The alsike clover and subterranean clover alone treatments produced significantly less ($P<0.01$) total dry matter than other clover treatments in the second year, and the red clover alone

treatment exceeded ($P<0.01$) all other treatments except lucerne, in the third year. Yields of ryegrass alone were significantly lower ($P<0.01$) than those of other treatments in the second and third years.

Lucerne production was similar to that of the higher-yielding clover treatments in the second year, although weeds made up over 30% of the total dry matter. In the third year lucerne yield exceeded that of the best clover treatment by 43%.

Total dry matter production over the three-year period was significantly higher ($P<0.01$) in the red clover alone treatment, and lower ($P<0.01$) in the ryegrass alone treatment, than in any other treatments. Lucerne production was similar to that of clover treatments of intermediate yields.

TABLE 7: SEASONAL AND ANNUAL SPECIES HERBAGE DRY MATTER PRODUCTION (3-YEAR MEANS) kg/ha, DUNBACK

Treatment	*Species*	*Spring*	*Summer*	*Autumn*	*Total sown*	*Volunteer Legume*
1	White clover	1910	690	210	2810	10
	Ryegrass	1 930	180	110	2220	
2	Red clover	1490		90	3 670	170
	Ryegrass	2090	2090	80	2300	
3	Sub. clover	2 120	60	100	2280	370
	Ryegrass	1 820	120	90	2030	
4	Alsike clover	1 300	800	40	2140	110
	Ryegrass	1 860	140	110	2110	
5	White clover	1620	420	130	2170	
	Red clover	470	690	40	1 200	40
	Ryegrass	1 960	140	100	2200	
6	White clover	1 600	640	150	2390	
	Sub. clover	450	10	40	500	30
	Ryegrass	1910	160	110	2 180	
7	Red clover	860	310	50	2220	
	Sub. clover	950	20	40	1010	190
	Ryegrass	1 900	140	90	2130	
8	White clover	1310	350	90	1 750	
	Red clover	320	800	30	1 150	20
	Sub. clover	340	0	20	360	
	Ryegrass	2000	130	110	2240	
9	Ryegrass	1 970	160	100	2230	460
10	Lucerne	1 980	2470	90	4540	0

Seasonal and Compositional Production

Maximum dry matter production of white, subterranean and alsike clovers occurred in spring, and that of red clover in summer. The spring production of white and subterranean clovers sown alone exceeded that of red and alsike clovers sown alone (Table 7).

Summer production of red clover was 40% greater than its spring production, but production of the other clovers dropped markedly in summer. Autumn clover yields were low.

Ryegrass and clover yields in most treatments were similar in spring and autumn, but clover yields exceeded those of ryegrass in summer except in the subterranean clover alone treatment.

In mixtures, white clover yields considerably exceeded those of red clover, which exceeded subterranean clover. Levels of volunteer clover, composed mainly of white clover, were low in most treatments.

Production in the first year was almost entirely from ryegrass, but clover dominated production in the second and third years (Fig. 2). The proportions of species in clover mixtures remained relatively constant in the second and third years, and the weed content of the lucerne treatment decreased markedly in the third.

Bet-wick

Results are given in Tables 8 and 9, and Fig. 3.

TABLE 8: TOTAL HERBAGE DRY MATTER PRODUCTION kg/ha, BERWICK

Treatment	1970-1	1971-2	1972-3	Total
1. White clover	**2 830** aA	3 790 aA	3 960 abAB	**10580** aA
2. Red clover	**2 780** aA	2 **660** cdBC	2 810 cC	8 250 abcAB
3. Sub. clover	**2 780** aA	2 330 dCD	3 340 abcABC	8 450 abcAB
4. Alsike clover	2 590 abA	3 140 bcAB	3 040 cBC	8 770 abAB
5. White + Red	2 540 abA	3 320 abAB	3 900 abAB	9 760 abAB
6. White + Sub.	2 480 abA	3 810 aA	**4010** aA	10300 abA
7. Red + Sub.	2 230 bA	2 290 dCD	3 270 bcABC	7 790 bcAB
8. White + Red + Sub.	2 860 aA	3 580 abA	3 920 abAB	10 **360** abA
9. Ryegrass	**2 590** abA	1 770 eD	1070 dD	**5430** cB
CV%	11.8	**12.0**	**14.9**	**16.0**

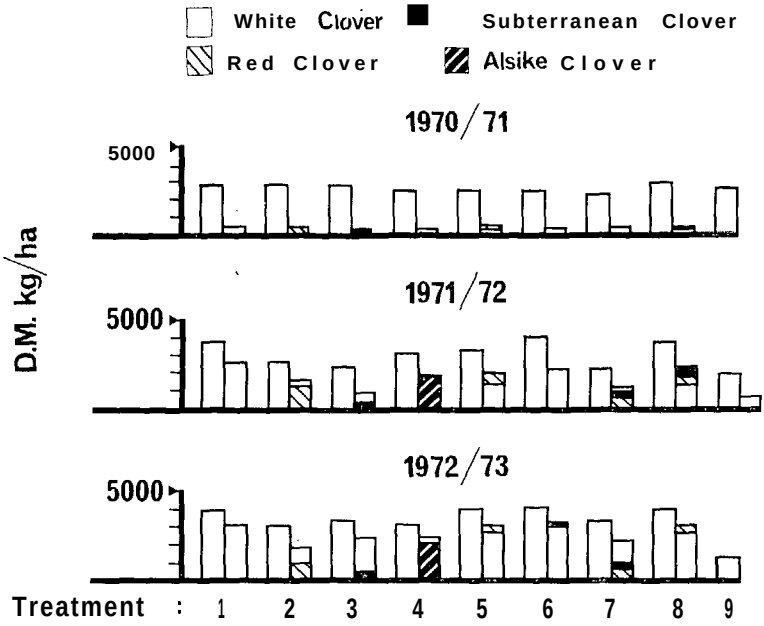

FIG. 3: Dry matter production, Berwick.

Total Dry Matter Yields

In the first year, yields of most treatments were similar. Production from white clover treatments increased in the second and third years to give significantly higher ($P<0.05$) total dry matter than most other treatments. Yield from the alsike clover treatment was similar to that of white clover treatments in the second year.

Ryegrass alone produced significantly less than other treatments in the second ($P<0.05$) and third ($P<0.01$) years.

Over the three-year period, total dry matter production of the clover treatments was similar, but the ryegrass alone produced significantly less ($P<0.05$).

Seasonal and Compositional Production

White, red and alsike clovers produced approximately twice as much dry matter in summer as in spring. White clover gave the greatest clover yield in each season, although spring production of alsike clover was similar to that of white clover. Subterranean clover production was low throughout (Table 9).

TABLE 9: SEASONAL AND ANNUAL SPECIES HERBAGE DRY MATTER PRODUCTION (3-YEAR MEANS) kg/ha, BERWICK

Treatment	Species	Spring	Summer	Autumn	Total Sown	Volunteer Legume
	White clover	570	1 180	40	1 790	170
	Ryegrass	590	370	160	1 120	
2	Red clover	290	510	40	840	330
	Ryegrass	610	350	170	1130	
3	Sub. clover	130	70	10	210	
	Ryegrass	700	430	200	1 330	840
4	Alsike clover	500	880	20	1 400	
	Ryegrass	510	390	190	1090	40
5	White clover	430	880	40	1 350	
	Red clover	70	240	20	330	70
	Ryegrass	590	330	160	1080	
6	White clover	590	1 150	40	1 780	
	Sub. clover	30	20	0	50	110
	Ryegrass	530	380	180	1090	
7	Red clover	140	260	20	420	
	Sub. clover	150	50	0	200	500
	Ryegrass	470	310	180	960	
8	White clover	420	960	30	1 410	
	Red clover	50	190	20	260	160
	Sub. clover	120	20	0	140	
	Ryegrass	640	370	200	1210	
9	Ryegrass	650	370	200	1 220	150

Ryegrass yields were similar to or exceeded total clover yields in most treatments in spring and autumn, Except for the subterranean clover alone treatment, clover yields were greater than ryegrass yields in summer.

White clover gave the highest legume yield of mixtures, and red clover gave twice the yield of subterranean clover where they were sown together.

Volunteer clover, mainly white, made up the majority of production of the subterranean clover alone treatment, and a substantial proportion of production of the red clover alone. Yield from volunteer clover was greater than that of either sown species in the red and subterranean clover mixture.

Production in the first year was almost entirely from ryegrass (Fig. 3). In the second and third years clover became dominant, mainly because of the amount of white clover present in most treatments. Only the alsike clover treatment remained relatively free of volunteer white clover.

DISCUSSION AND CONCLUSIONS

Although the technique of mowing and discarding clippings places limitations on the practical applications of this type of trial, the relative production -of species gives some indication of their usefulness in pasture situations.

At Invermay, total herbage dry matter production was high from treatments which included white or red clover (Table 4) . Clover contributions to production were important in all seasons, but especially so in summer when ryegrass production dropped markedly (Table 5) .

White clover dominated legume production when sown in mixtures, and legume yields of mixtures seldom exceeded those of white or red clover sown alone (Fig. 1).

As the persistence of red clover is generally low, and as volunteer white clover appears to make up an increasing proportion of legume production in pasture sown only with red clover (Fig. 1), sowing red clover alone is recommended only for seed production.

The results of this trial thus suggested that white clover should be sown with ryegrass for consistently high pasture production on sites similar to Invermay.

As lucerne gave very high yields at the Invermay site, consideration should be given to making greater use of it on similar high-fertility soils, in preference to lower-producing clover/ryegrass pasture.

Dry matter production of red clover alone sown with ryegrass was clearly superior to that of the other pasture mixtures at Dunback (Table 6). This agrees with the findings of McLeod (1968) who showed that red clover outyielded both white and subterranean clovers when grown alone, and boosted legume production in most combinations, in a similar environment in South Canterbury. The major factor in this superiority was the good summer growth of red clover in the dry climate of the district. Summer clover production of the red clover alone treatment exceeded twice that of other clovers sown alone, and was greater than that of other clovers when sown in mixtures (Table 7).

Spring total production was similar in treatments containing red or white clover, and autumn production was low in all treatments.

The high total production of the red clover alone treatment and its potential for providing summer grazing when production of other pasture species is declining show that red clover is a suitable legume for sowing in pasture mixtures in a dry, moderately fertile environment.

Subterranean clover production was comparatively better at Dunback than at the other sites. This may have been due to the adaptation of subterranean clover to low rainfall and regular summer droughts (Smethan, 1968). However, the overall production of subterranean clover does not justify its use as a pasture species at any of the sites described in this paper, although as an annual its seeding and therefore herbage production may have been adversely affected by the mowing management.

The very low production of lucerne at Dunback in the first year is considered normal for this district (G. G. Cossens, pers. comm.). The high second and third year yields indicate the usefulness of lucerne as a hay crop under this climatic regime.

White clover gave the best legume yields at the Berwick site, although total yields were similar in most treatments (Tables 8 and 9). Legume yields of clover mixtures showed little or no advantage over that of white clover alone (Fig. 3).

Legume production of alsike clover was comparatively high at this site. This agrees with the results of Clifford (1973), who showed alsike clover production to be similar to that of white clover when sown with grasses on a site of moderate to low fertility in the MacKenzie Basin in South Canterbury. Clifford suggested that alsike clover has better ability than other legumes to withstand severe frost and cold.

The results of this trial show white clover to be the pasture legume best suited to the less favourable environment of sites such as that at Bet-wick.

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