Proceedings of the New Zealand Grassland Association, 47: 53-62 (1986)

PERFORMANCE OF SUBTERRANEAN AND WHITE CLOVER VARIETIES IN DRY HILL COUNTRY

D.F. CHAPMAN, G.W. SHEATH', M.J. MACFARLANE',
P.J. RUMBALL[2], B.M. COOPER[2], G. CROUCHLEY[3],
J.H. HOGLUND[4], and K.H. WIDDUP[5].
Grasslands Division, DSIR, Palmerston North,
[2]Kaikohe, [4]Lincoln and [5]Gore,
MAF, Whatawhata Hill Country Research Station,
'Hamilton and [3]Hastings.

Abstract

Nine subterranean clover cultivars and 10 white clover varieties, differing in characters such as morphology and flowering date (sub clover), or growth habit and seeding ability (white clover), where evaluated for persistence and production at 8 summer-dry hill country sites. Results for the first 3-4 years suggest the sub clovers on the New Zealand Acceptable Herbage Cultivars List (Mt Barker, Tallarook, Woogenellup, Clare) should be revised. Regeneration of Woogenellup and Clare was consistently poor, while Tallarook performed well at most sites. The current unavailability of Tallarook seed means Mt Barker is the only effective option for grasslands in most of New Zealand. Cultivars of the sub clover subspecies *yanninicum* (Larisa, Trikkala) showed promise for winter-wet, summer dry environments, as did Nangeela in winter-cold environments. A late-flowering, prostrate, low oestrogenic sub clover similar to Tallarook would be well suited to large areas of summer-dry hill country.

There is a clear need for a white clover cultivar adapted to summer-dry hill country as none of the varieties tested survived severe moisture stress at 2 sites (Hawke's Bay, North Canterbury), and none performed consistently well at the other sites. New Zealand varieties (Hula, Pitau, G18 and a hill country selection) showed best persistence and production. The overseas cultivars Haifa, Tamar, Louisiana and Clarence Valley, which are all adapted to dry conditions in their country of origin, were consistently poor. Firm selection criteria for dry hill country were not Identified, though stolon density and seeding ability should be incorporated and the strong influence of management and soil fertility on genotype performance must be recognised.

Keywords: subterranean clover (*Trifolium subterraneum* L.), white clover (*Trifolium repens* L.), hill country, dryland, cultivars, persistence, genotype-environmental interaction.

INTRODUCTION

Soil moisture deficits are a major limitation to pasture growth in New Zealand hill country. Several regions, e.g. the east coast of both islands, North Canterbury, Marlborough and parts of the Volcanic Plateau, Bay of Plenty, Waikato and Northland experience moisture stress in most years. In addition, moisture deficits occur on a more localised scale (e.g. steep north faces) within regions generally considered summer-moist or wet. Additional stresses imposed by fertility, temperature and grazing result in low levels of productive legumes especially white clover (*Trifolium repens* L.). Usually the most abundant legumes are low-producing annuals such as suckling clover (*T.* dubium Sibth.) and clustered clover (*T. glomeratum* L.).

White and subterranean (sub) clover offer the greatest potential for improving legume production in seasonally dry areas. Current recommendations for both species in these environments are based on cultivars which were not bred for the environment and which therefore do not necessarily possess the characteristics required for persistence and production (Chapman and Macfarlane 1985). There is however, considerable variation within both species in survival-related features, such as morphology, time of flowering and adaptation to different soil conditions in sub-clover, and vegetative habit, root morphology and seedling regeneration in white clover, which could be exploited to provide more suitable cultivars.

This experiment evaluated 9 sub clover cultivars and 10 white clover varieties for persistence and production at several summer-dry sites throughout New Zealand. The varieties assessed differed in some or all of the characteristics outlined above. The aims of the experiment were: 1) to evaluate existing genetic material of both species in a range of summer-dry hill country environments, and 2) to identify important characteristics involved in persistence and production of sub and white clover in summer-dry hill country so that these may be incorporated within any future plant breeding or plant introduction programmes.

TABLE 1: Site characteristics.

Site	Region	Soil type	Slope	Olsen P
Kaikohe	Northland	Shallow podzol	1-7°	9
Whatawhata	Waikato	Steepland sedimentary	25-35"	14
Wairakei	Central Plateau	Pumice	25"	28
Porangahau	Central Hawke's Bay	Yellow grey earth	5"	7
Ballantrae	Southern Hawke's Bay	Yellow grey-yellow brown earth intergrade	24"	4
Rawhiti	Wairarapa	Central yellow brown earth	24"	3
Carvossa	North Canterbury	Skeletal hill	15-20°	16
Hokonui	Southland	Yellow grey earth	15"	6-10

METHODS

Brief details of the eight sites are given in Table 1. Wairakei, Porangahau and Carvossa were consistently dry, with moisture deficits lasting from November to May at the latter site. Kaikohe, Whatawhata and Rawhiti all experienced drought in 1983, while Ballantrae suffered less severe moisture deficits. The Hokonui site, while located in a generally-dry zone of Southland, received consistently high summer rainfall during the evaluation period.

In autumn 1981, 4 replicate plots of each sub clover cultivar (Table 2) and white clover variety (Table 4) were established at each site (except Hokonui) by either transplanting glasshouse-raised seedlings or sowing seed. The Hokonui site was established in spring 1981. Sub clovers at Porangahau and Rawhiti established poorly and were replanted in 1982 at Porangahau and 1983 at Rawhiti. At Wairakei, contamination by resident white clover necessitated replanting white clover plots at a new site in autumn 1983. Additional transplants covered losses during the first winter and spring at all sites, and replanting to maintain at least the original planting density continued for the next 2 years at Whatawhata and Wairakei. At all sites except Whatawhata and Wairakei management was lenient during the establishment year to allow plots to bulk up and set seed during the first spring/summer.

Measurements and regular defoliation began about a year after planting at most sites. No white or sub clover herbage was harvested at Porangahau or Carvossa. Plots were mob stocked with sheep at intervals depending on rate of herbage accumulation except at Carvossa where plots were set stocked most of the year and sheep were removed 2-3 weeks prior to assessments. Herbage was harvested before grazing and dissected to measure clover herbage accumulation. At Porangahau and Carvossa relative sub clover yields were estimated by visual assessment of leaf bulk. Sub clover production at Hokonui was estimated by both herbage cuts and visual assessment. During May/June each re-establishment year sub clover seedling density was counted at all sites except Kaikohe where density was scored visually. White clover stolon densities were counted during winter at Kaikohe, Whatawhata, Ballantrae, Rawhiti and Hokonui, and in December 1984 at Wairakei.

TABLE 2: Sub clover herbage accumulation relative to Mt Barker (= 100) at 8 sites; actual DM values (kg/ha/yr) for Mt Barker are in parentheses.

	Site							
Cultivar	Kaikohe	Whatawhata	Wairakei	Ballantrae	Rawhiti	Porangahau[1]	Carvossa[1]	Hokonui
Seaton Park	151	72	41	80		59	56	36
Trikkala	185	83	40	88	243	64	75	59
Howard	154	103	58	212	132	64	80	103
Woogenellup	70	108	66	97	350	79	96	116
Clare	85	56	37	43	94	71	61	58
Mt Barker	100 (2160)	100 (1809)	100 (570)	100 (238)	100 (222)	100	100	100 (1830)
Larisa	308	66	47	190	537	99	49	62
Nangeela	81	88	100	262	199	100	104	151
Tallarook	144	123	165	358	114	109	61	124
Stage of trial (years)	2nd, 3rd	1st-4th	1st-3rd	2nd, 3rd	2nd	2nd, 3rd	1st-4th	2nd

[1] Leaf bulk assessed by visual scores.

Plots received minimal inputs of fertiliser, corresponding to approximately maintenance levels of superphosphate for each site.

Results from mainly the second and third years of the trial are presented where available.

RESULTS AND DISCUSSION

Sub Clover

While some of the cultivars evaluated have been widely used in New Zealand (Mt Barker, Tallarook, Woogenellup), all are of immediate Australian origin. They are only a sample of the cultivars available in Australia, and represent ranges of adaptation to soil conditions, flowering/reseeding times and morphological habit (Collins et al. 1984). They are mainly from the *Trifolium* subterraneum subspecies subterraneum, but Trikkala and Larisa belong to subsp. yanninicum (characterised by tolerance of winter-wet soils) and Clare belongs to subsp. brachycalycinum (adapted to alkaline soils). As listed in Table 2, the cultivars are in order of flowering date from earliest (Seaton Park, peaking in mid-September) to latest (Tallarook, mid-November). In Clare, and to a certain extent in Woogenellup and Seaton Park, leaf and runner (stem) habit is open and aerial, while at the other extreme Mt Barker and Tallarook are of a tight crown form.

Mt Barker was used as the standard (100) for relative cultivar ranking of herbage accumulation (Table 2) and sub clover density in May/June (Table 3). Except for yield at Rawhiti and density at Ballantrae this standard was, at least, an intermediate performer.

Seaton Park did not yield well (except for the one-year data set from Rawhiti) and regeneration was variable. The opportunity for spring growth in this cultivar is limited by its early maturing habit, and the aerial nature of runners and flowers make it vulnerable to hard grazing during reseeding.

Despite good regeneration at several sites, Trikkala yielded well at only Kaikohe and Rawhiti. However, even more striking at these two sites was the superiority of Larisa, especially in yield. The adaptation of these subsp. yanninicum cultivars to the winter-wet Kaikohe podzol and Rawhiti central yellow brown earth highlight the potential of this subspecies in such soils that also subsequently experience summer-dry conditions. Previously, the poorer-performing cultivars Tallarook and Mt Barker have been used on these soils. A wider range of subsp. yanninicum types (e.g. Meteora) should be screened to identify the most suitable replacement for these older cultivars.

The relative yield of Woogenellup was variable, and could not be considered consistently superior to that of Mt Barker. Further, regeneration of Woogenellup was very poor relative to the other cultivars (except at Hokonui), a reflection of its erect reseeding habit and propensity to "false strike". Within a self-perpetuating system, this poor regeneration must ultimately lead to low production levels. Similarly, the erect cultivar Clare was extremely poor in regenerating new populations. Although existing plants grew vigorously, they were few in number and Clare yields were consistently poor. While both Woogenellup and Clare are currently on the New Zealand Acceptable Herbage Cultivar List, neither can be realistically recommended for situations where hard sheep grazing may occur during October-November. High winter-early spring growth rates of Woogenellup may provide some valuable feed in areas that experience early and prolonged dry conditions (e.g. North Canterbury), but grazing must be at least lenient ($>$ 5cm residual height) for a period of 3-4 weeks during peak re-seeding in spring. Woogenellup may have a temporary role in these areas, but a long term objective should be to identify a more manageable, productive mid-season cultivar.

TABLE 3: Sub clover plant regeneration in May/June relative to Mt Barker (= 100) at 8 sites. Actual seedling densities for Mt Barker (No./m²) are in parentheses.

	Site							
Cultivar	Kaikohe[1]	Whatawhata	Wairakei	Ballantrae	Rawhiti	Porangahau	Carvossa	Hokonui
Seaton Park	157	131	58	265	99	20	74	69
Trikkala	190	73	64	355	82	43	88	158
Howard	156	87	34	641	34	64	49	146
Woogenellup	68	36	28	159	87	38	1	385
Clare	64	15	41	27	70	61	66	71
Mt Barker	100	100 (365)	100 (115)	100 (89)	100 (1263)	100 (796)	100 (707)	100 (720)
Larisa	281	21	87	211	64	54	24	157
Nangeela	73	25	88	322	40	56	83	193
Tallarook	182	117	155	446	101	175	48	291
Stage of trial (years)	2nd.4th	2nd-4th	2nd-5th	3rd, 4th	2nd	5th	2nd, 3rd	2nd, 3rd

[1] Regeneration assessed by visual scores

TABLE 4: Characteristics of the white clover varieties evaluated.

Cultivar/Variety	Origins	Morphology and Growth
Kent wild white	English ecotype	Small-leaved, prostrate, very dense. Slow winter/spring growth, good summer production.
Hill country	NZ selection of hill country ecotypes	Small-leaved, prostrate, very dense. Good summer growth.
Grasslands Huia	NZ cultivar developed from local ecotypes	Dense, medium-leaved. Reasonable winter growth in mild conditions. NZ standard.
Clarence Valley	Australian ecotype	Facultative annual, medium-leaved, open, free-seeding.
Louisiana S1	American variety based on Louisiana ecotype	Facultative annual, medium-leaved, erect, open. Extended flowering season.
Grasslands Pitau	NZ cultivar developed from Huia x winter active Spanish material, backcrossed to Huia	Moderately dense, medium-large leaved. Cool season active especially in northern regions.
Italy x NZ	NZ selection of crosses between NZ (mainly Huia) and Italian material.	Large-leaved, tall, dense. Good summer and cool-season growth.
Haifa	Australian cultivar developed from material collected in Israel	Large-leaved, moderately erect and dense. Heat tolerant, free-seeding, winter growth. Taprooted.
Tamar	Israeli cultivar	Large-leaved, tall, open. Free-seeding Taprooted.
G18	NZ selection of crosses between Pitau and Ladino (large-leaved cultivar of Italian origin)	Large-leaved, erect, open. Good summer and cool season growth. Some tendency toward taprootedness.

The performance of Howard followed no discernable pattern, although it did well at both Ballantrae and Kaikohe. Nangeela was more consistent and yielded well at all but the 2 most northern sites (Kaikohe, Whatawhata) despite variable and occasionally poor regeneration. Nangeela may perform better in cooler winter environments. However, among the later-flowering cultivars, the most outstanding feature was the consistently high yielding and regenerative performance of Tallarook. Only at the 2 winter-wet sites (Kaikohe, Rawhiti) and the very dry Carvossa site was Tallarook well behind the best cultivars. The later flowering/maturing characteristic of this cultivar allows spring growing conditions to be fully exploited, and the prostrate reseeding habit allows reliably high levels of regeneration under intensive sheep grazing. Tallarook has long been recommended for summer-dry environments in New Zealand despite its high oestrogen content (Saxby 1956). On the basis of this series, Tallarook should still be recommended, but seed supplies are currently unavailable. Ideally a low-oestrogen sub clover with flowering and growth habits similar to Tallarook should be identified for New Zealand grasslands.

White Clover

Characteristics of the white clover varieties evaluated are shown in Table 4. These varieties provided variation in 3 survival-related characters: shoot morphology (ranging from small-leaved, prostrate and dense types to large-leaved, open types), growth habit (from perennial New Zealand varieties to the facultative annuals Louisiana S1 and Clarence Valley which are essentially winter annuals), and root morphology (with some taproot production in G18, Tamar and Haifa, and more typical fibrous root production in the others). In Table 4, varieties are listed in approximate order of increasing leaf size. Only Huia and Pitau are on the New Zealand Acceptable Herbage Cultivars List and currently available for use in New Zealand.

White clover production was highest at the warm Kaikohe, and cool, moist Hokonui sites (Table 5). Low production at Ballantrae and Rawhiti reflects low phosphate levels at these sites (Table 1). No varieties survived regular and severe soil moisture deficits during the late spring-autumn period at Porangahau or Carvossa. Despite good seed set in the first year, only a few seedlings established at Carvossa, mainly in patterns determined by microsite and with no apparent cultivar differences, Production from Wairakei and, to a lesser extent, Whatawhata reflects mainly potential growth of varieties as plots were replanted to a minimum density each year.,

The varieties separated into 2 broad groups on the basis of production (Table 5). The first group contained the New Zealand cultivars and selections, and the second group the overseas free-seeders and facultative annuals. Kent was either intermediate, or among the second group, despite sometimes high stolon density (Table 6), and showed little merit for summer-dry hill country.

New Zealand cultivars and selections persisted and produced best at all sites where herbage accumulation was measured (Table 5). G18 ranked highest at Kaikohe (where its resistance to stem nematode was a major contributing factor) and Hokonui, and also performed well at Whatawhata. At other sites, Huia, Pitau and G18 all persisted reasonably well, against expectations based on survival of larger-leaved varieties observed in other hill country evaluations (Suckling and Forde 1978, Williams et al. 1982, Charlton 1984). Good persistence of these varieties is probably related to trial management, where grazing was infrequent compared to sustainable stocking rate systems (either continuously or rotationally grazed) at high levels of utilisation (Clark et *al.* 1984). Under more frequent and severe defoliation, larger-leaved varieties are placed under stress by frequent removal of leaves (Korte and Parsons 1984), a phenomenon smaller-leaved varieties are able to avoid to some extent because some leaves are borne below the grazing horizon,

G18	138	180	149	68	68			102
Pitau	103	95	106	87	77			99
Huia	100	100	100	100	100			100
	(2707)	(749)	(212)	(660)	(470)	(0)	(0)	(5574)
Italy x NZ	127	126	153	62	98			81
Hill Country	105	88	110	68	89			86
Kent	103	92[1]	39	22	52’			38
Haifa	88	66’	66	18	50			20
Tamar	103	79’	191	25	83’			18
Louisiana	78	129’	250	28	68			14
Clarence Valley	71	84’	110	20	63’			4
Stage of trial (years)	2nd.4th	2nd.4th	2nd	2nd, 3rd	2nd, 3rd			2nd

[1] High resident clover contamination in latter years.

TABLE 6: White clover stolon density relative to Huia (= 100) at 6 sites; actual densities (No./m²) for Huia are in parentheses.

Cultivar/Variety	Kaikohe	Whatawhata	Wairakei	Ballantrae	Rawhiti	Hokonui
G18	89	93	80		112	43
Pitau	83	69	84	76	73	53
Huia	100	100	100	100	100	100
	(4100)	(560)	(297)	(1040)	(710)	(‘2450)
Italy x NZ	141	109	121	44	85	65
Hill Country	219	122	184	277	193	133
Kent	138	123	135	46	77	122
Haifa	15	58	44	16	35	12
Tamar	30	61	93	77	104	14
Louisiana	44	79	86	54	31	16
Clarence Valley	76	56	54	51	55	24
Stage of trial (years)	2nd, 3rd	2nd, 3rd	2nd	2nd, 3rd	2nd, 3rd	2nd

Under favourable growing conditions, plant stature and productivity are generally positively related (Williams and Caradus 1979). G 18 and Pitau performed relatively as good as or better than Huia where growing conditions, especially soil fertility, were favourable (i.e. Kaikohe, Whatawhata, Hokonui), and relatively poorer than Huia under more difficult conditions for white clover growth (i.e. Ballantrae, Rawhiti). In general, these varieties had good stolon density relative to the overseas varieties (Table 6), though stolon density and yield showed no obvious positive relationship across all sites and varieties. There may be a role for Huia and Pitau types on hill country where fertility is adequate and grazing is reiatively infrequent, e.g. mob stocking.

The performance of the Hill Country selection was only moderate relative to the other New Zealand varieties. Two factors contributed to this: firstly grazing management encouraged production of the larger-leaved varieties, and secondly the evaluation period was probably too short to establish the full merit of this plant type. Evidence suggests the hill country cultivar Tahora, which is based partly on this selection, is relatively slow to establish and form the dense stolon population for which it is noted (Chapman and Fletcher 1985, D.F. Chapman, unpub. data). The performance of Italy x NZ was also only moderate at most sites, though it showed some potential for higher winter growth rates.

The overseas varieties Haifa, Tamar, Louisiana and Clarence Valley persisted poorly at all sites. Several factors were involved; these included susceptibility to stem nematode and rust at Kaikohe, and generally low stolon density (Table 6). Louisiana and Clarence Valley especially are adapted to regions with Mediterranean-type climate (i.e. reliable onset of a regular summer-dry period followed by regular autumn rainfall) which none of these sites experienced. Both these varieties lost density during summer which was not recovered in autumn. All 4 varieties set considerable quantities of seed at most sites, and seedling numbers in autumn and winter were often high. However, seedling survival was apparently poor because these varieties all declined quite rapidly.

A tendency for taproot production in Haifa and Tamar did not appear to aid survival of these cultivars, though this characteristic may have contributed to the relatively good performance of G 18, especially at Whatawhata. Other characteristics of Haifa and Tamar, e.g. low stolon density, were overriding factors in their poor performance and did not allow reasonable evaluation of taprootedness as a survival mechanism. The precise roles of seedling regeneration and taprootedness in white clover persistence in dry hill country remain uncertain, and would be better evaluated using material more suited to New Zealand conditions than the overseas varieties grown in this series. Both characteristics are found in white clover populations resident in New Zealand summer-dry hill country (e.g. Macfarlane and Sheath 1984). It is, however, doubtful whether white clover can thrive in environments where moisture stress is regular and severe, and where good seedling establishment is required to maintain the population in most years, because of its small seed and slow seedling growth. In these environments, the need is for larger-seeded legumes with rapid establishment and good cool-season growth, e.g. subterranean clover.

CONCLUSIONS

While there was considerable variation in the performance of cultivars within sites, all except the relatively wet Hokonui site were suitable environments for the establishment and regeneration of sub clover populations. Where white clover failed to persist at the very dry Carvossa and Porangahau sites sub clover increased in abundance, and at the less severe sites sub and white clover generally achieved a similar herbage production range. It must be emphasised that the results presented cover only 3-4 years, and that some of the trials are continuing under more intensive management. Nevertheless, several clear trends in the performance of various plant types have emerged, enabling identification of some important characteristics, especially for subterranean clover.

These trials indicated the potential of cultivars of the sub clover subsp. yanninicum (e.g. Larisa) for winter-wet, summer-dry soils, and the possible value of Nangeela for winter-cool environments. Regeneration of Clare and Woogenellup was consistently poor, and given the importance of this process to long-term production the presence of these cultivars on the Acceptable Herbage Cultivars List is questioned. The latest flowering cultivar, Tallarook, performed consistently well, but unavailability of Tallarook seed means Mt Barker is the only effective alternative for farmers at present. A reliable seed supply of a late flowering, prostrate, low-oestrogen sub clover should be established for New Zealand hill country conditions.

In contrast, firm criteria for improved plant performance of white clover in dry environments did not emerge from this evaluation. No varieties survived severe moisture deficits at 2 sites, and none were consistently outstanding at the other sites. For favourable conditions of soil fertility and grazing pressure, there may be merit in selecting plants with larger leaf size than currently being sought in hill country breeding programmes. However, stolon density must also be maintained, and should probably be associated with high seed production. There is a clear need for a white clover cultivar adapted to summer-dry intensively-grazed hill country, although extremely dry sites, e.g. North Canterbury, must be considered marginal for this species.

Acknowledgments

We thank all those who helped with trial maintenance and data collection, and owners and managers of Rawhiti, Carvossa and Fairplace Stations for access to trial sites and provision of stock. Dr W.M. Williams, formerly of Grasslands Division, DSIR, Palmerston North, was an initial co-ordinator of this evaluation, and P.S. Harris and C.D. Meurk held responsibility for the Rawhiti and Hokonui sites respectively.

References

Chapman, D.F.; Fletcher, R.H. 1985. N.Z. J. agric. Res. 28: 191-199.

Chapman, D.F.: Macfarlane, M.J. 1985. In 'Using Herbage Cultivars' (R.Burgess and J.Brock eds.), Grasslands Research Practice Series No. 3, N.Z. Grassld Ass.: 20-30.

Charlton, J.F.L. 1984. *Proc. N.Z. Grassld* Ass. 45: 131-139.

Clark, D.A.; Chapman, D.F.; Land, C.A.; Dymock, N. 1984. N.Z. J. agric. Res. 27: 289-301.

Collins, W.J.; Francis, C.M.; Quinlivan, B.J. 1984. Western Australian Department of Agriculture Bulletin No. 4083.

Korte, C.J.; Parsons, A.J. 1984. *Proc.* N.Z. Grassld Ass. 45: 118-123.

Macfarlane. M.J.: Sheath, G.W. 1984. *Proc. N.Z. Grass/d. Ass. 45:* 140-150.

Saxby, S.H.; 1956. N.Z. J. agric. 92: 518-527.

Suckling, F.E.T.; Forde, M.B. 1978. N.Z. *J. agric. Res. 21:* 499-508.

Williams, W.M.; Caradus, J.R. 1979. *Proc. N.Z. Grassld* Ass. 40: 162-169

Williams, W.M.; Lambert, M.G.; Caradus, J.R. 1982 *Ibid* 43: 188-195.