EVALUATION OF CLOVERS ON SANDY COASTAL SOIL

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Abstract

In evaluations of clover performances on summer-dry Himatangi sandy soil, it was found that none could match lucerne over summer. Emphasis was therefore placed on production in autumn-winter-early spring when lucerne growth was slow. Evaluations of some winter annual clover species suggested that *Trifolium spumosum*, *T. pallidum*, *T. resupinatum*, and *T. vesiculosum* would justify further investigation, along with *T. subterraneum* which is already used in pastures on this soil type.

Among the perennial clover species, Kenya white clover (*T. semipilosum*) showed outstanding recovery from drought and was the only species to produce significantly in autumn. However, it failed to grow in winter-early spring. Within red clover, materials of New Zealand × Moroccan origin substantially outproduced the commercial cultivars. Within white clover, material from Israel, Italy and Lebanon, as well as progeny of a selected New Zealand plant, showed more rapid recovery from drought stress and subsequently better winter growth than New Zealand commercial material ('Grasslands Huia').

The wider use of plant material of Mediterranean origin and of plants collected in New Zealand dryland pastures is advocated in development of clover cultivars for New Zealand dryland situations.

INTRODUCTION

APPROXIMATELY three million hectares of farmland in New Zealand are regularly limited in productivity by shortage of useful rain in summer and autumn, and many perennial pasture plants are killed or severely damaged during this period by water stress and high temperatures. When significant rain does occur late in the season, there is a delay in pasture production owing to depleted and damaged plant populations. If rain does not come until early winter, recovery may be further slowed by cold temperatures. Only about one-eighth of this area is potentially irrigable. Thus improvement of productivity on most of this land is largely dependent on improvement of pasture yields under dryland conditions.

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Plant breeding is one way in which yields of dryland pastures may be improved. Two approaches are possible: (1) To develop plants which grow well during the dry period, or (2) to develop plants which survive the dry period undamaged and respond rapidly to autumn rain.

The present paper reports results of evaluations of a range of clover *(Trifolium)* species, cultivars, and breeding lines grown under dryland conditions on coastal sandy soil in the southern North Island.

EXPERIMENTAL

Plant materials and their origins are listed in Tables 1, 2 and 3. Three separate experiments were established on adjacent land areas in autumn 1973 on an excessively drained Himatangi sandy soil at the Ministry of Agriculture and Fisheries Field Research Area, Flock House, near Bulls. The water-table is below the reach of grass and clover roots during summer (Cowie and Hall, 1965) making this soil type suitable for studies of summer-drought tolerance of pasture species. All trials were randomized block designs with three replications.

EXPERIMENT 1

The species listed in Table 1 were grown as pure swards in plots 1.5 m square separated by 1 m mown pathways. Most species were established from seed sown at the following rates (corrected for germination percentage) : *Trifolium subterraneum* 20 kg/ha; *T. hirtum* 10 kg/ha; *Medicago sativa* 7 kg/ha; *T. fragiferum, T. repens, T. hybridum* 5 kg/ha. Because of seed shortage, *T. burchellianum, T. semipilosum* and *T. pratense* were established by planting glasshouse-grown plants on a 15 cm square grid. All species were inoculated with effective *Rhizobium* strains except *T. repens* and *T. subterraneum* whose rhizobia were naturalized in the soil.

The first year was an establishment period in which data were not collected. Plots were trimmed at intervals to ensure optimum establishment. In the second autumn (1974), *T. subterraneum* and *T. hirtum* re-established naturally from fallen seed while the perennial species were assessed for their abilities to survive summer drought in the vegetative state by measurement of their recovery growth from autumn 1974 onwards. Harvests were made when each species was judged to have reached maximum

TABLE 1: ANNUAL AND SEASONAL HERBAGE YIELDS FOR MOWN PLOTS

Species	Cultivar‡/Origin	Annual/ Perennial	Yield (kg/ha) DM Autumn	Winter	Spring	Summer	Total
T. subterraneum	Woogenellup‡, Aust.	A	—	2550	2500	—	5050
T. subterraneum	Mt Barker‡, Aust.	A	—	2100	2880	—	4980
T. subterraneum	Geraldton, Aust.	A	—	1960	1740	—	3700†
T. pratense	4n Morocco × Hamua	P	—	1530	4030	—	5560
T. subterraneum	Clare‡, Aust.	A	—	1510	2520	—	4030
T. repens	Huia‡, N.Z.	P	—	1400	4250	—	5650
T. fragiferum	Palestine‡	P	—	1080	3410	—	4490
T. pratense	2n Morocco × Hamua	P		920	3780		4700
T. fragiferum	Argentina	P	—	850	3720	—	4560
T. semipilosum	Kenya (4n) CPI 53357	P	730	—	3760	—	4490
T. pratense	Hamua‡, N.Z.	P	—	250	2750	—	3000††
T. hirtum	Kondinin, Aust.	A	—	—	3680	—	3680†
T. hybridum	Tambov, USSR	P	—	—	2720	—	2720††
T. pratense	Pawera‡, N.Z.	P	—	—	1760	—	1760††
T. pratense	Turoa‡, N.Z.	P	—	—	1530	—	1530††
T. hybridum	Tetra, Sweden	P	—	—	1400	—	1400††
T. hybridum	McKenzie Basin, N.Z.	P	—	—	1250	—	1250††
T. hybridum	Canada	P	—	—	1200	—	1200††
T. fragiferum	O'Connor‡, Aust.	P	—	—	—	—	—
T. burchellianum	Kenya	P	—	—	—	—	—
Medicago sativa	Wairau‡, N.Z.	P	—	—	8790	3060	11 850**

‡N.Z. Schedule of Acceptable Herbage Cultivars.
†Signif. poorer than Huia white clover ($P < 0.05$).
**Signif. better than Huia white clover ($P < 0.01$).
††Signif. poorer than Huia white clover ($P < 0.01$).

yield. Yields were measured on a 1 m^2 area per plot cut to approximately 5 cm above ground level. Plots received dressings of superphosphate of 250 kg/ha in autumn and spring of both years. Measurements ended in March 1975.

EXPERIMENT 2

The experiment summarized in Table 2 was a spaced plant trial established from glasshouse-grown plants. Species were selected on the basis of promise shown in an earlier trial at Palmerston North (conducted by the late G. S. Harris). Plots consisted of 10 plants in two rows of five, spaced at 30 cm within and 60 cm between rows. Plants were grazed at intervals by sheep and were scored for growth by eye on a 0 to 5 scale. Annual dressings of superphosphate at 250 kg/ha were applied. *Rhizobium* inoculum was available only for *T. vesiculosum*, *T. semipilosum*, *T. pratense*, and *T. rubterrunsum*.

EXPERIMENT 3

The white clover lines (Table 3) were sown at 3 kg/ha (corrected for germination percentage) in plots 3 m X 1 m. The entire trial was sown with 'Grasslands Apanui' cocksfoot (*Dactylis glomerata*) at 10 kg/ha and 'Graslands Matua' prairie grass (*Bromus catharticus*) at 40 kg/ha. The trial was occasionally grazed by sheep, and superphosphate at 250 kg/ha was applied in spring of both years. White clover performances were scored for each plot on a 0 to 10 scale. Data are presented for the second year following summer drought.

RESULTS

WEATHER

Meteorological data for 1974 at the trial site have been presented elsewhere (Williams *et al.*, 1975). Drought conditions occurred from October 1973 until January 1974 with rainfall 155 mm (125 mm less than average for that period). A temporary recovery occurred in February 1974 but March had only 26 mm rainfall. Plant death occurred as early as November 1973 in some clover species. The winter and spring of 1974 were warmer than average with fewer frosts. January to March 1975 was very dry with rainfall only i 13 mm (77 mm less than average) for the period.

LUCERNE GROWTH

Table 1 shows that, in the cutting trial, Wairau lucerne yielded more than twice the dry matter of the best clovers for both spring and the whole year. Furthermore, lucerne was the only legume species in this trial to produce significant growth in the dry summer months. These results are in agreement with those of Smith and Stiefel (1978), indicating the importance of lucerne on this soil type. Lucerne did not produce harvests in the cool seasons.

CLOVER SPECIES GROWTH

Results of growing a range of clover species in the cutting trial and spaced plant trial are given in Tables 1 and 2, respectively. In the light of the outstanding growth of lucerne compared with the clovers in spring and summer on this soil type, emphasis has been given to clover yields in the cool seasons when lucerne growth was slow.

TABLE 2: RELATIVE GROWTH SCORES FOR INTRODUCED *TRIFOLIUM* SPECIES GROWN AS SPACED PLANTS

Species	Cultivar/Origin	Annual/ Perennial	Relative Yield Scores‡ Jul. 1973 Winter	Relative Yield Scores‡ Mar. 1974 Summer Drought Recovery
T. spumosum	Morocco	A	137**	—
T. pallidum	Algeria	A	131**	—
T. subterraneum	Mt. Barker, Aust.	A	126**	—
T. squarrosum	Italy	A	121**	—
T. resupinatum	Morocco	A	119**	—
T. subterraneum	Tallarook, Aust.	A	116*	—
T. isodon	Morocco	A	116*	—
T. vesiculosum	Yuchi, USA	A	111	—
T. pratense	Pawera, N.Z.	P	104	91
T. repens	Huia, N.Z.	P	100	100
T. semipilosum	Kenya	P	97	132
T. hybridum	Canada	P	94	56†
T. isodon	Morocco	A	90	—
T. neglectum	USSR	P	90	73
T. thallii	Italy	P	74††	13††
T. pannonicum	Hungary	P	62††	73
T. hohenackeri	Turkey	P	48††	101
T. parviflorum	Portugal	P	44††	0††
T. trichocephalum	USSR	P	35††	48††
T. alpestre	USSR	P	34††	27††

‡Yields expressed relative to Huia white clover (= 100).
Summer drought *recovery* of annuals was not assessed.
*,**Significantly better yield score than Huia ($P < 0.05, 0.01$)
†,††Significantly *poorer* yield score than Huia ($P < 0.05, 0.01$).

Annual Clovers

Annual clovers are adapted to survival of hot, dry summers by formation of seeds in early summer. Germination occurs mainly in autumn and growth in winter and spring. They are, therefore, often well adapted to cool season growth and generally produced more dry matter in winter than the perennial species (e.g., Table 2).

Of the subterranean clover cultivars grown, best winter yields (Table 1) were obtained from Woogenellup, a mid-season cultivar (Quinlivan et *al.,* 1968). Other annual species to grow well in winter were *T. spumosum, T. pallidurn, T. squarrosum, T. resupinatum* and one line of *T. isodon*. *T. vesiculosum* (Table 2) gave reasonable winter growth and later gave high spring yields. *T. hirtum* (Table 1) growth was poor.

Perennial Clovers

Perennial clovers survive the dry season in the vegetative state, and do not usually set seed as profusely as the annuals, although some seed drop usually occurs. None of the perennial clover species grown produced significantly more winter growth (or total growth) than white clover. Kenya white clover *(T. semipilosum)* was of interest because it was the only species which grew rapidly in autumn following a severe summer drought (Tables 1 and 2). Its later growth in winter was negligible although it recovered by late spring. Palestine strawberry clover *(T. fragiferum)* and a similar line from Argentina produced less than Huia but not significantly so. The performances of *T. hybridum* (alsike clover), *T. burchellianum,* and O'Connor's strawberry clover were very poor.

Red Clover

Table 1 shows that the best red clovers in this study were Moroccan x New Zealand hybrids developed at Grasslands (Anderson, 1970). Both diploid and tetraploid forms of this hybrid significantly outyielded Hamua which was the best of the three commercial cultivars of red clover.

White Clover

Results of observations on three dates during the white clover trial are given in Table 3. The first observation, early in the drought period, indicated that Mediterranean material of Algerian

TABLE 3: RELATIVE YIELD SCORES FOR WHITE CLOVER GRAZED PLOTS

Line/Origin	Relative Yield Scores (Huia = 100) Dec. 1973 Early Drought	Jul. 1974 Winter	Oct. 1974 Early Spring
Israel X Pitau	200	300**	380”’
Lebanon	60	300**	367**
Morocco x Algeria	100	213*	333**
Israel x Huia	140	275**	317**
Haifa, Israel	120	225”	317**
Ladino x Pitau	200	213”	300’”
‘Regal’ ladino, USA	80	163	300**
‘Merit’ ladino, USA	60	63	267*
‘Lodi’ ladino, Italy	80	88	267*
Kaikohe x Huia	120	213’	233
Ladino x Huia	140	138	233
Spain	220”	138	167
‘Pilgrim’ ladino, USA	60	25	150
Grasslands Pitau, N.Z.	140	138	150
Algeria X Pitau	240*	150	150
Algeria	300**	150	100
Grasslands Huia, N.Z.	100	100	100
Louisiana S-l. USA	140	75	83
Louisiana ex Kenya	140	35	83
South Africa	80	38	67
Argentina	60	13	33
Cyanide-free, N.Z.	40	13	17
Kent, U.K.	20	Trace	0

*,**Yield score significantly better than Huia ($P < 0.05, 0.01$).

and Spanish background was best while other materials, notably Kentish, quickly deteriorated under the dry conditions. However, for recovery growth after the drought (winter and spring growth), other lines of Mediterranean origin were best — e.g., Israel, Lebanon, Morocco, Algeria, as well as those with a ladino (Italian) background. A cross involving a New Zealand plant selected for drought tolerance at Kaikohe by J. P. Lambert showed good recovery. At the same time, lines of Kentish, Argentinian and New Zealand cyanide-free origin virtually disappeared.

DISCUSSION

Results indicate that it is unlikely that we will be able to achieve significant productivity from clovers during the period of water stress. However, a great deal of useful variation in the abilities of clovers to survive drought and provide cool season growth has been revealed.

Present results emphasize the importance of plant materials of Mediterranean origin for improvement of pasture growth in New Zealand dryland situations. The success of the winter annual adaptation to summer-dry situations is recognized by the wide use of subterranean clover on summer-dry soils, including the coastal soil used here. The possibility that some other annual clover species might also be useful on this soil type has been raised. It has also been recently shown that another winter annual legume, serradella, may have potential for this class of land (Williams et *al.,* 1975).

Among the perennial species, the superiority of Mediterranean sources for drought survival and subsequent cool season growth was striking: Palestine strawberry clover, Moroccan red clover, and white clovers from Israel, Lebanon, Morocco, Algeria, and Italy. The potential of Mediterranean sources for improvement of cool season growth of New Zealand pasture plants has been noted before (Barclay, 1960, 1963), but the associated tolerance of drought has not been given the same emphasis. Drought tolerance and cool season growth potential are closely tied together in the adaptation of perennial plants to Mediterranean climatic patterns. Neal-Smith (1970), in Australia, has noted superior heat and drought tolerance of white clovers from Israel, Lebanon, and Portugal.

Present results indicate that incorporation of Moroccan material into New Zealand red clovers should dramatically improve drought tolerance and cool season productivity, especially at the tetraploid level. Anderson (1970) noted that Moroccan red clover was more persistent than Hamua under dryland conditions in Hawke’s Bay. In white clover, use of material from Israel, Lebanon, and Italy might be expected to increase white clover drought tolerance and cool season growth at least up to that of subterranean clover and other annuals. However, the use of Mediterranean material will be restricted to regions where winter cold does not lead to severe frost damage.

One African species studied, which has recently shown promise in Queensland (Jones, 1973) warrants further attention. Kenya white clover *(T. semipilosum)* showed outstanding drought survival and subsequent autumn growth. However, it failed to grow after being cut in June and produced no more growth until late spring. *T. semipilosum* is taxonomically closely related to 7’. *repens* and it has been a logical step to attempt to use *T. semipilosum* as a source of drought tolerance for breeding into white clover. However, attempts to cross the two species have not been successful (White and Williams, 1976).

The wider use of plant material of Mediterranean origin and of plants collected in New Zealand dryland pastures is advocated in development of clover cultivars for New Zealand dryland situations.

ACKNOWLEDGEMENTS

The authors wish to thank W. Stiefel, Ministry of Agriculture and Fisheries, Flock House Field Research Area, for his interest and assistance. R. M. Greenwood, Applied Biochemistry Division, DSIR, kindly provided *Rhizobium* strains for inoculation.

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