PROMISING PASTURE SPECIES FOR DROUGHT PRONE SLOPES IN THE SOUTH ISLAND HIGH COUNTRY

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ABSTRACT

Seventy four legume and 44 grass cultivars and lines were assessed over a widely variable landscape mosaic on lower sunny faces at Tara Hills Research Station, Omarama from September 1984 until May 1989.

The best adapted legume species were crown vetch, lucerne, birdsfoot trefoil and *Dorycnium hirsutum*. By contrast, the conventional species white, red, alsike and subterranean clovers performed poorly and showed significant plant survival only in the most favourable areas. Crown vetch, G34, clearly showed the best combination of agronomic attributes, followed by a birdsfoot trefoil line derived from plants surviving from long-term trials in the Mackenzie Country. Summer production of lucerne was seriously affected by insect damage.

Among the grasses, cocksfoot cultivars and lines had the best overall combination of attributes, but in this trial, tall fescue and ryegrass showed significantly better frost tolerance. A Grasslands tall fescue selection, T1327, also had a good combination of agronomic attributes. Significantly lower plant numbers in tall fescue cultivars and lines than in ryegrass and cocksfoot were mainly attributable to the higher establishment losses in this species. Ryegrass performed better than expected. The recently released cultivar Ceres Marathon and two Tara Hills ecotypes ranked highly for plant survival and vigour, but had only moderate drought tolerance. Establishment difficulties seriously affected the subsequent performance of the Grasslands cultivars Maru phalaris and Tiki and Hakari bromegrasses.

Several of the most promising alternative legumes and grass species and cultivars in this trial are being further assessed in large scale on-farm trials.

INTRODUCTION

Lack of winter-early spring feed is a barrier to animal production in the hill and high country. Lower slopes, particularly sunny aspects, have the potential to be developed and provide cost effective feed during this period by the establishment of a sustainable legume base for cool season active grasses. However, most traditionally used species and cultivars are unsuited to lower altitude drought-prone country because they are either difficult to establish or lack sufficient drought tolerance to persist and spread (Keoghan, 1985).

Work commenced in September 1984 on a lower sunny face on Tara Hills Research Station, Omarama, with the following objective:

To test the persistence and production of a wide range of conventional and alternative legumes and grasses when integrated with resident species on a low sunny face. Of highest priority were the identification of cool season active grasses, and drought-tolerant perennial legumes.

The results of this trial have allowed further work to centre on establishment and management of the most promising species and cultivars through large scale on farm trials (Keoghan *et al.*, 1989).

EXPERIMENTAL

Soils: The lower sunny faces of the South Island hill and high country fall within the Brown-grey and Yellow-grey earth soil groups. They have a total area of 360,000 hectares and are associated with lower shady faces of similar area. The latter will of course have a better moisture regime in average to moist seasons; however, in dry periods their moisture status will be little different from their sunny aspect counterparts. So

in a time of drought the effective area of dry sunny faces is doubled to 720,000 hectares and sown species present must have similar drought tolerance on all lower aspects whether sunny or shady. Omitted from the lower sunny group are many intermediate and high terrace and fan soils and their stony shallow associates. The legume and grass species assessed in this work therefore have a much wider practical significance than the term "lower faces" would suggest.

METHODS

The trials was designed with four replicates each placed on the "lower sunny" landscape so as to represent as much variation in soil depth, moisture content and resident vegetation cover as possible within the general climate of the site (Table 1); a landscape mosaic design.

A wide range of legume and grass germplasm (Table 2) was raised in the greenhouse and then established in spring 1984 and again in 1985, on the trial site by individually transplanting into 25-plant rows with 20 cm between plants. Plants were watered in and during dry periods for each of the following seasons to ensure establishment and therefore the opportunity to measure performance. After transplanting, the plants were scored regularly for survival, seasonal performance, drought and frost tolerance. The trial areas were mob grazed twice a year with sheep.

Data collected during the 1987-88 season was analysed through analysis of variance and ranking within legume and grass groups. Data was assessed for consistency with results from previous years.

RESULTS AND DISCUSSION

Legumes: Species which showed most promise for plant survival and vigour across the landscape mosaic of the trial, were lucerne (*Medicago sativa*), birdsfoot trefoil (*Lotus corniculatus*), G34 crown vetch (*Coronilla varia*), Caucasian clover (*Trifolium ambiguum*), and PN canary clover (*Dorycnium hirsutum*) (Figure 1, Table 3). Of these, lucerne is the only legume readily available commercially. It is well suited to semi-arid and sub-humid fertile soils. The low vigour scores recorded for lucerne in summer were due to severe defoliation by Lepidopterus insects. Because the other four legumes are more tolerant to low soil fertility and insect pests than lucerne they have potential as alternative species in a range of environments and systems where lucerne is poorly or marginally suited.

Conventional species such as white clover (*Trifolium repens*), subterranean clover (*T. subterranean*) and alsike clover (*T. hybridum*) showed poor plant survival and vigour. None of the 18 white clover accessions survived except for Grasslands Pitau, Grasslands Kopu and an F_2 hybrid from the Grasslands DSIR regional breeding programme in Southland (Widdup *et al.*, 1989). These were only a few plants in an especially favourable area of the trial. A Canadian cultivar, Aurora and two lines from the USSR performed best of the 7 alsike accessions. Even so these were confined to the most favourable areas (about 26%) of the trial; none of them showed persistence outside these areas (Figure 1).

The results confirmed that subterranean clovers only perform well in favourable years and lack persistence on the lower sunny faces. Mt Barker, Woogenellop, Howard, Seaton Park and Trikkala showed good autumn vigour only in the mild, wet autumn of 1987.

None of 12 red clover (*T. pratense*) cultivars or lines survived after 1987 despite the lax grazing of the trial, confirming the lack of persistence of this species beyond three to four years (Cossens & Radcliffe, 1978; Greenwood & Sheath, 1982).

Table 1: Site characteristics of the lower sunny face, Tara Hills.

Aspect:	North	**Altitude:**	520m
Slope:	25 °	**Soil:**	Dry Subhygrous Yellow Grey Earth
Rainfall:	524 mm p.a.	**Sunshine:**	2,080 hours p.a.

	January	July
Mean maximum air temperature (°C):	27.5	11.4
Mean minimum air temperature (°C):	5.7	-3.3

Screen Frost: 115 days/year **Air Frost:** 156 days/year

Table 2: Legumes and grasses established on a lower sunny face at Tara Hills, Omarama

Species	Common Name	Number of Accessions/Lines
LEGUMES		
Trifolium repens	White clover	18
T. subterraneum	Subterranean clover	9
T. pratense	Red clover	5
T. hybridum	Alsike clover	7
T. ambiquum	Caucasian clover	2
T. balansae	Balansa clover	3
Lotus corniculatus	Birdsfoot trefoil	8
L. corniculatus x L. pedunculatus	Lotus hybrid (G4712)	1
Medicago sativa	Lucerne	5
M. arborea	Tree medick	1
Ornithopus spp.	Serradella	2
Onobrychis viciifolia	Sainfoin	1
Astragalus cicer	Milk vetch (Lutana)	1
Coronilla varia	Crown vetch (AL 1349)(G34)	1
Dorycnium pentaphyllum	Prostrate Canary clover	1
D. hirsutum	Hairy Canary clover	1
Lupinus polyphyllus	Russell lupin	1
Chamaecytisus palmensis	Tagasaste (tree lucerne)	1
Hedysarum coronarium	Sulla	1
GRASSES		
Lolium perenne	Perennial ryegrass	15
L. multiflorum	Italian ryegrass	2
Dactylis glomerata	Cocksfoot	5
D. woronowii		1
Bromus willdenowii	Prairie grass	2
B. inermis	Smooth brome (Grasslands Tiki)	1
B. marginatus	Mountain brome (Grasslands Hakari)	1
B. scoparius	Grasslands	1
B. carinatus	cv. Deborah	1
Agrostis castennana	Dryland browntop	1
Festuca arundinacea	Tall fescue	4
F. rubra	Creeping red fescue	2
Cynosurus cristatus	Crested dogstail	1
Elytrigia intermedia	Pubescent wheatgrass (luna)	1
Holcus lanatus	Yorkshire fog	2
Phalaris aquatica	Canary grass (Grasslands Maru)	1
Secale montanum	Mountain rye	2
Poa pratensis	Kentucky bluegrass	1
Arrhenatherum elatius	Tall oatgrass (Tara)	1

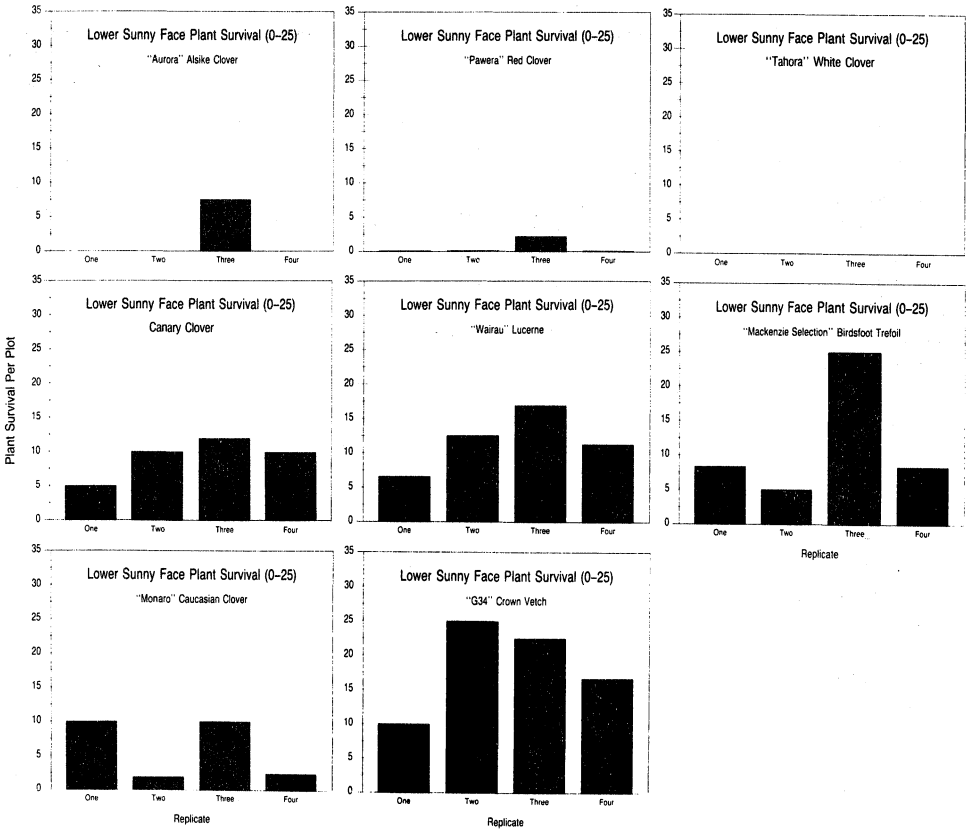

Figure 1. Survival of legumes on the lower sunny face, Omarama.

Crown vetch is summer productive and winter dormant; it is suited to soils of moderate pH, but once established will tolerate acid soils (Charlton, 1983). Low seedling vigour means that it is slow to establish form seed but establishment using vegetative propagation may be feasible under some conditions. The crown vetch, 'G34', which has been selected for high forage production performed better than any other legume in the trial, ranking first for plant survival ($P < 0.05$), summer and autumn vigour. Plantlets are appearing from rhizones up to 1 m from parent plants. It is not yet commercially available, but crown vetch produces a fair seed crop (Rolston, pers.comm.) and should be available within the next two years.

Birdsfoot trefoil is commercially available in limited quantities. All of the eight cultivars or lines included in the trial performed well (Table 3). 'Mackenzie S2086' derived from plants surviving from long-term trials in the Mackenzie country, showed the best combination of agronomic attributes. Granger was the most successful commercially available cultivar. Recent research into inoculation and establishment (Lowther & Trainor, 1988; Lowther *et al.*, 1989) and edaphic tolerance (Chapman *et al.*, 1989) have led to management recommendations to improve establishment, persistence and productivity.

Caucasian clover is a rhizomatous, perennial species which will tolerate acid soil conditions (Bryant, 1974). Establishment is slow because of low seedling vigour; a high proportion of early growth is concentrated in the development of a network of rhizomes. Establishment using vegetative propagates may be feasible under some conditions. The cultivar Monaro showed most promise in this trial. It was slow to establish above ground

Table 3: **Species of legume and their accessions/lines which show most promise for the low sunny face on Tara Hills, Omarama.**

Species (Accession/line)	Survival		Autumn Vigour 1987		Summer Vigour 1988		Drought Tolerance	
	Rank	Plants /Plot 1988	Rank	Score	Rank	Score	Rank	Score
Crown vetch	1	19.25	1	4.50	1	4.75	16	2.75
Lucerne								
'Wairau'	=3	12.00	=16	3.00	=48	2.75	53	2.00*
WI318	6	10.00	=24	2.75	=48	2.75	=43	2.25*
Grasslands 'Oranga'	2	12.25	=6	3.50	23	3.25	=43	2.25*
CRD3E2A1 x Washoe	7	8.75	=24	2.75	56	2.50	57	1.25*
Birdsfoot trefoil								
Granger	12	5.00	12	3.25	11	3.75	1	4.50
S2110 'Guelph'	16	2.50	31	2.59	9	3.95	4	4.15
(David Scott) Empire	8	7.53	46	2.25	8	3.99	15	2.82
Maitland/MacKenzie S2085	11	5.20	=16	3.00	=4	4.50	12	3.25
MacKenzie S2086	=3	12.00	2	4.25	=4	4.50	39	2.50
Viking	10	5.75	=16	3.00	18	3.50	8	3.75
S1035	13	4.25	=6	3.50	6	4.33	6	3.90
Vega II	14	4.00	=16	3.00	21	3.35	14	2.98
Caucasian Clover								
Monaro	9	6.00	55	1.75	27	2.97	5	4.00
Canary Clover								
Dorycnium hirsutum	5	10.25	=24	2.75	7	4.00	2	4.25
Total Number of Legumes		74		74		74		74
SEM		1.72		0.44		0.45		0.50

Score: 1 = lowest; 5 = highest. * Results confounded with *Eurythecta* damage.

biomass but showed good persistence and spread and young plants have established from rhizomes up to 30 cm from parent plants. It is also one of the more drought tolerant cultivars (rank 5). Monaro is also under grazing assessment on a mid-altitude shady face at Tara Hills and to date is the most promising legume in terms of persistence and spread (Allan, pers.comm.).

Canary clover is a perennial subshrub up to 0.5 m tall and 0.1 m in diameter. In this trial, shrubs showed good plant survival (rank 5), drought tolerance (rank 2) and summer and autumn vigour (rank 7 and 24= respectively). It has shown promise for revegetation in drought prone and semi-arid areas of the South Island (Wills *et al.*, 1989), and has a place in pasture systems to complement grasses such as phalaris (*Phalaris aquatica*) or cocksfoot (Brosnan, 1987). Because it is a drought-tolerant subshrub, *D. hirsutum* has considerable potential as a "fodder bank" species.

Grasses: Cocksfoot (*Dactylis glomerata*) and perennial ryegrass (*Lolium perenne*) showed more vigour than any other grass species and cocksfoot was most consistent across the replicates (Table 4, Figure 2).

Table 4: **Species of grass and their accession/lines which show most promise for the low sunny face on Tara Hills, Omarama.**

Species (Accession/line)	Survival		Autumn Vigour 1987		Summer Vigour 1988		Frost Tolerance		Drought Tolerance	
	Rank	Plants /Plot 1988	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Ryegrass										
Marathon	13	11.25	=7	3.25	=9	3.25	=13	3.0	30	2.75
Tara hills mid-shady	11	11.75	=7	3.25	1	4.25	24	2.75	=24	3.00
Tara Hills low-sunny	8	13.75	11	3.00	=9	3.25	32	2.50	38	2.00
Cocksfoot										
'Wana'	2	16.50	3	3.75	4	3.75	40	1.50	=24	3.00
'Apanui'	4	15.00	=1	4.00	=2	4.00	=37	1.75	=12	3.50
'Tara Hills'	7	14.50	=1	4.00	=2	4.00	=37	1.75	8	3.75
Dactylis woronowii										
K2341	1	16.75	=17	2.75	7	3.50	43	0.75	=24	3.00
Tall fescue										
'Aronde'	27	5.75	=17	2.75	=9	3.25	=13	3.00	=12	3.50
T1327	20	9.00	=7	3.25	=9	3.25	7	3.25	2	4.75
Total Number of Grasses		44		44		44		44		44
SEM		1.72		0.44		0.45		0.37		0.50

Score: 1 = lowest; 5 = highest.

Cocksfoot cultivars which performed particularly well were Apanui and Wana. Under the present grazing management at Tara Hills, where the dry lower slopes are set stocked in the spring after lambing (October - November) and intermittently grazed during the winter, Apanui does not persist (Allan & Chapman, 1987) but Wana could be a substitute as it is well known to withstand set stocking (Rumball, 1982). The most promising ryegrass lines/cultivars were 'Tara Hill low sunny', 'Tara Hills mid shady' and Ceres Marathon. The 'Tara Hills' lines are known to be high in endophyte (Wedderburn, pers. comm.), which may explain their high level of persistence. Clearly, factors other than drought, such as insect damage, and grazing severity can influence the longevity of ryegrass.

Tall fescue (*Festuca arundinaceae*) cultivars/accessions showed a good combination of agronomic attributes. Despite low initial establishment plants are persisting across all four replicates (Figure 2). Cultivar Aronde and accession 'T1327' combined good drought tolerance with autumn vigour and the ability to carry green material into winter; they were superior to Grasslands Roa and cv. Nomad.

Grasslands Matua prairie grass (*Bromus willdenowii*) (Frazer, 1982) has been selected for cool season activity. Despite good initial establishment, Matua has failed to persist in this trial (Figure 2).

Poor establishment meant that Maru phalaris, which is well known to provide standing feed into winter/early spring (Rumball, 1980) did not perform in this trial.

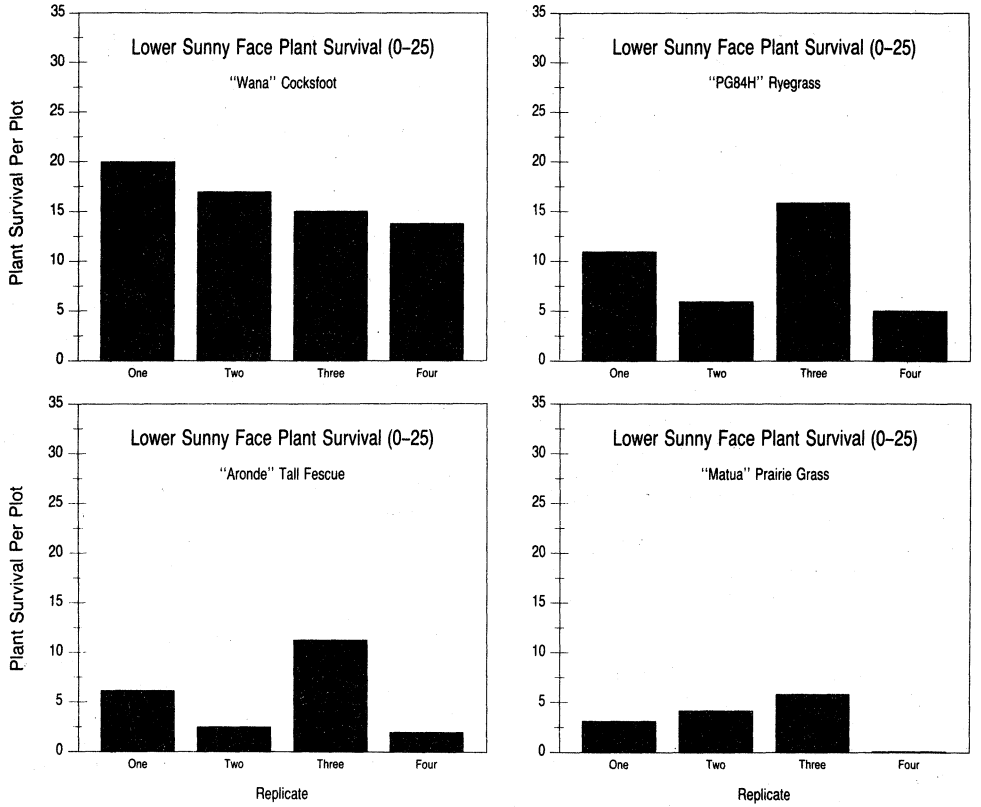

Figure 2: Survival of grasses on the lower sunny face, Omarama.

RECOMMENDATIONS AND FUTURE RESEARCH

Legumes: Lucerne is often the best choice for the semi-arid zone when appropriate management is combined with correct choice of cultivar, correct choice of site and adequate plant nutrition. If the lower slopes to be improved can be direct drilled, then lucerne can be successfully established. Seed is commercially available cultivars which are more pest and disease resistant than those previously available have been identified (Purves & Wynn-Williams, 1989).

Birdsfoot trefoil is a valid alternative, especially on soils where lucerne is poorly or marginally suited. Seed is available in limited quantity and research to identify successful establishment practices is making it an increasingly sound option. A New Zealand cultivar for semi-arid and drought-prone area (Widdup *et al.*, 1987) will be available commercially by 1992-93.

In future, Caucasian clover, crown vetch and *Dorycnium hirsutum* may become part of sustainable farm systems. Future work on their establishment and management is planned, so that when seed is commercially available farmers will be able to introduce these alternative legumes into their pasture systems with confidence.

Cool season active grasses may be introduced along with the legumes, capitalizing on the persistent legume base.

Cocksfoot and perhaps ryegrass should be used if improvement is by oversowing. Tall fescue combines good drought tolerance with cool season activity, and should at this stage be introduced by direct drilling or cultivation.

Research into successful establishment practices is required to ensure that the excellent potential of these species for developing sustainable pasture production systems in drought-prone environments can be capitalized on. The role of these alternative species in different regions, environments, landscapes and managements systems will be examined through large scale on-farm trials.

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