Alternative grass options for dry east coast and downland pastoral systems

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Abstract

An on-farm investigative development approach has been used to evaluate the performance of eight dryland forage grass species over a period of eighteen months in the Hakataremea Valley, South Canterbury. Species under examination included Black Mountain rye (*Secale montanum*), cocksfoot (*Dactylis glomerata*), upland brome (*Bromus marginatus*), smooth brome (*Bromus inermis*), wheatgrass (*Elytrigia intermedia*), phalaris (*Phalaris aquatica*), tall oat grass (*Arrhenatherum elatius*) and perennial ryegrass (*Lolium perenne*). At this site Black Mountain rye is highly promising as a palatable and drought, frost and pest tolerant species that provides large amounts of special purpose greenfeed particularly in early spring and autumn. Cocksfoot, tall oat grass, smooth brome and wheatgrass also have potential as productive and sustainable pasture grasses with wide seasonal growth patterns. In contrast, perennial ryegrass appears to possess few of these valued agronomic attributes.

Additional key words: *Hakataremea Valley, South Island, dryland, seasonal pasture production, ryegrass, Black Mountain rye, upland brome, smooth brome, pubescent wheatgrass, phalaris, cocksfoot, tall oat grass.*

Introduction

A series of droughts, particularly in Spring and Autumn, throughout the 1980's in the coastal area of North Otago and South Canterbury, has heightened farmer awareness of the need for more sustainable and ecologically sound pastoral systems. Production from traditional ryegrass/white clover based pastures has been poor and in many cases, particularly where low endophyte ryegrass was used, the sown species have simply died from moisture stress combined with Argentine stem weevil and grass grub attack.

These experiences have emphasised the limitations of relying on broadly adaptable 'national' cultivars over a wide range of environments and farming systems. Timely selection and breeding programmes over the last 20 years to develop better suited pasture plants for specific regions, environments and farming systems (Corkill *et al.*, 1981) are providing the agronomist and farmer with a host of alternative grass options.

However, adoption of some new species and cultivars can be poor (Lancashire, 1985) and often marred by misunderstnandings about their agronomic attributes and environmental adaptation, particularly in dry regions (Keoghan and Fraser, 1989; Belgrave *et al.*, 1990). Although considerable information is available in research journals, at conferences and in the agricultural press, a survey (Belgrave *et al.*, 1990) of farmers in 1985 revealed that 76% considered paddock-sized demonstrations on commercial units and on-farm situations are probably the best way to increase the rate of adoption of novel or alternative cultivars.

An on-farm investigative development trial was set up on moderately fertile, drought prone, arable soils early in 1990 in the Hakataremea Valley, South Canterbury, to assess the suitability of various grass and legume combinations to persist and provide winter grazing for sheep. Establishment and early persistence and production of the grasses under test are reported in this paper.

Materials and Methods

The trial site was located at Belfield Station, Hakataremea Valley, altitude 250 m.a.s.l, on a Struan-Oturehua, southern yellow-grey earth soil. The mean annual rainfall is 478 mm (range 279-665 mm), but its effectiveness is lessened by its maximum being in the summer period of high temperature and evaporation the latter resulting from dry northwesterly föehn winds. Frosts of -10°C are common during the winter, and light snowfalls can occur periodically. Cold temperatures can limit plant growth from May to September. Mean monthly rainfall and temperature recordings from February 1990 to June 1991 during the trial period are presented in Figure 1 and Table 1 respectively.

Site preparation

Glyphosate (Round-up) herbicide was applied at a rate of 3 litres/ha (360 g/L active ingredient) with Pulse penetrant and surfactant (100 mls/100 L water) in October 1989 and the site was 'maxitilled' in early January 1990. New and recent drought tolerant grass and legume species (Table 2) were cross-drilled using a Duncan 750 Tillseeder within a 10 ha fully randomised block design using four replicates. The total drilled area was 17.5 ha. including replicated surrounds. The site received an initial topdressing of 1000 kg/ha lime and sulphur superphosphate was drilled with the seed at a rate of 200 kg/ha.

The four replicates were arranged so that adjacent replicates had rows and columns in opposite directions to cover all the aspects of the terrain. In effect replicates one and two were arranged as above on a northwesterly facing terrace slopes with well draining deep soil exposed to the prevailing summer wind (hereafter termed slope). Replicates three and four were similarly arranged on lower, flat, thinner, stony, river-outwash soil, but less exposed to the prevailing summer wind (hereafter termed flat). The trial paddock had a previous history of low endophyte ryegrass/subterranean/white clover. A dense subterranean clover component remained on the terrace slopes and to a lesser extent on the lower land following trial establishment.

Conditions at drilling were dry, but this was soon followed by rain and mild temperatures. Appropriate inoculums were used for all sown legumes and seeding rates were adjusted to sow similar numbers of viable legume and grass seeds (Table 2).

Measurements

Five weeks after drilling, seedlings were counted using 20 random placements of a 0.25 m sq quadrat per plot and plants were further counted in May 1990, November 1990, and May 1991.

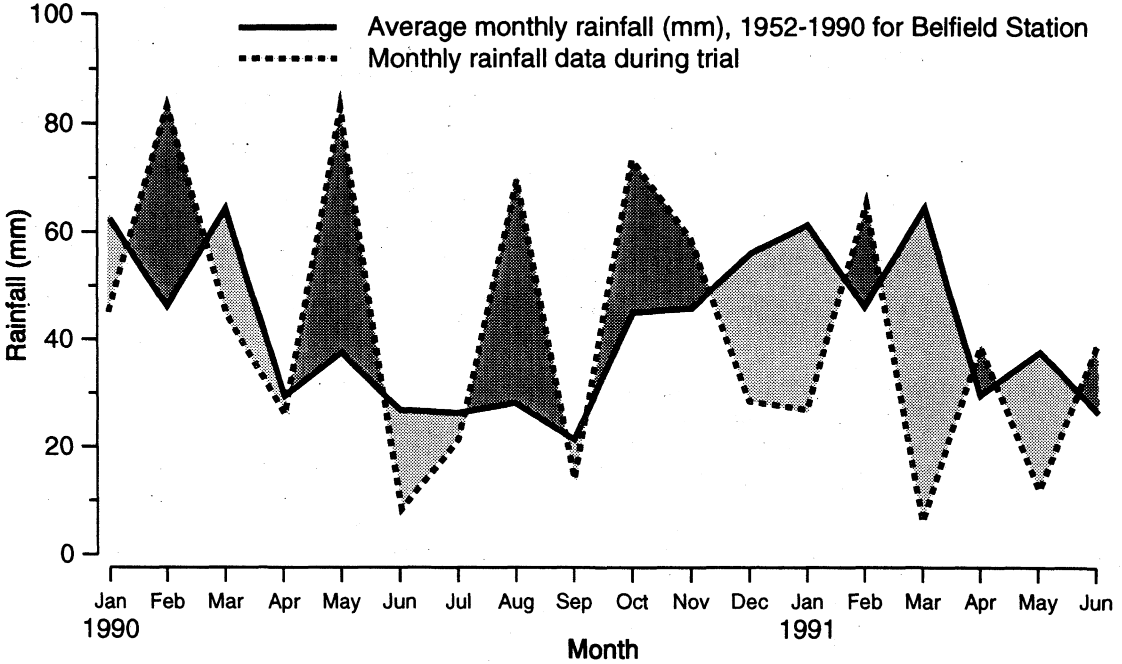

Figure 1. Average (1952-1990) monthly rainfall (mm) and monthly rainfall at the site during the trial.

Table 1. Mean monthly maximum and minimum temperatures at Belfield Station during the trial.

Month	Minimum (°C)	Maximum (°C)
1990		
February	8.8	26.4
March	8.5	25.7
April	1.8	22.3
May	3.2	18.1
June	- 3.8	11.2
July	- 4.5	12.5
August	- 3.8	12.6
September	- 1.0	18.1
October	3.5	21.5
November	3.4	23.2
December	6.9	26.2
1991		
January	9.0	31.7
February	7.2	26.7
March	6.1	25.5
April	1.8	19.9
May	- 0.9	17.5
June	- 3.4	11.4

Accumulated herbage mass was assessed using a pasture probe (Mosaic systems Ltd., Palmerston North). Fifty probe readings were taken per plot (total = 216 plots) pre and post grazing and herbage dissections were taken randomly within each plot along a grass row in November 1990 to determine the proportion of sown grasses.

Herbage samples of grasses were taken in June 1991 from all replicates and combined for digestibility analysis. Digestibility of plant tissue was determined by the cellulose degradation technique at the Invermay Agricultural Research Centre laboratories (NIR Feed Analysis FQO4). Since no routine laboratory determination exist locally for metabolisable energy and digestibility, the values were adjusted according to British MAFF Technical Bulletin No 33 to estimate *in vivo* values.

Grazing management

The trial was first grazed in August 1990 following establishment (Autumn 1990) by mob stocking with cross-bred sheep (90 SU/ha). Stock were kept on until approximately 50% of the herbage was utilised. Following grazing the trial was spelled until regrowth height was approximately 20 cm. This management required the trial to be grazed again in November 1990, March 1991 and June 1991.

Results

Rainfall for the year since sowing has been slightly above average. Autumn and spring 1990 rainfall was above the 1952-90 average (Fig. 1), yet, summer 1990/1991 and autumn 1991 rainfall was substantially lower than the average.

Plant population

Favourable rainfall and mild temperatures during autumn 1990 generally provided for successful early establishment of grasses trialled. Initial plant populations for ryegrass, phalaris, wheatgrass and upland brome were greater than for Black Mountain rye, cocksfoot, tall oat grass and smooth brome (Table 3). Ryegrass and wheatgrass plant populations were slightly less in replicates on the flat compared to replicates on the slope, but, plant numbers of other grasses were the same. Numbers of cocksfoot seedlings established were lower than expected considering the high numbers of viable seed sown. However, by November 1990 all grass

Table 2. Seed weights, sowing rates, viable seeds sown and seedling numbers five weeks after sowing.

Species	Seed weight (g/1,000 seeds)	Sowing rate (kg/ha)	Viable seeds sown/m²	Seedling numbers/m²	% Seedlings from viable seed sown
Black Mountain rye	11.7	35.0	251	44	17.5
Hakari upland brome	9.4	27.0	230	88	38.0
Tiki smooth brome	4.1	11.0	201	28	13.9
Mandan wheatgrass	6.0	33.0	506	112	22.1
Maru phalaris	1.75	8.0	367	132	37.0
Kara cocksfoot	1.0	9.0	705	48	6.8
Tall oat grass	2.6	7.0	210	32	15.2
McKenzie hard ryegrass	1.9	17.0	877	172	19.6

Table 3. Early grass plant population changes between landforms within the trial site (plants/m²).

	Mar 1990		May 1990		November 1990		June 1991	
	Slope	Flat	Slope	Flat	Slope	Flat	Slope	Flat
McKenzie hard ryegrass	188.0	155.6	165.2	86.0	196.0	55.6	101.6	43.6
Mandan wheatgrass	132.4	93.2	96.2	58.8	26.0	22.0	39.2	38.4
Tiki smooth brome	26.6	36.4	27.2	44.4	10.8	15.6	14.8	29.2
Maru phalaris	138.0	127.2	96.4	82.4	26.8	22.0	41.2	38.2
Tall oat grass	30.8	32.8	30.4	26.4	17.6	15.2	17.6	20.4
Hakari upland brome	96.4	80.4	65.6	51.6	32.0	17.6	32.8	26.8
Kara cocksfoot	33.6	59.6	41.2	49.6	18.4	17.2	19.6	27.6
Black Mountain rye	47.6	42.0	30.0	28.2	15.6	16.4	19.6	23.2
SED (between sites)	2.95		1.83		1.30		1.37	
SED (within grasses)	12.42		7.42		5.35		5.32	

populations were similar, except for ryegrass which remained higher throughout the evaluation period.

Plant populations of ryegrass, phalaris, wheatgrass, Black Mountain rye and upland brome declined markedly during the period March 1990 to May 1990. Cocksfoot, tall oat grass and smooth brome populations remained the same during this period. However, all grass populations throughout the replicated area declined over the winter/spring period, except ryegrass which declined only on the flat. Generally, the decline in grass plant populations was greater on the flat than on the slopes.

In contrast, during the summer/autumn period there was no further reductions in grass plant populations, except for ryegrass which declined significantly, especially from the slopes. Populations of wheatgrass, smooth brome grass and phalaris increased slightly throughout the replicated area.

Pasture production

Measurements taken in August 1990 showed that mountain rye outyielded other grasses (Fig. 2). Upland brome, phalaris and ryegrass had similar yields and were higher than cocksfoot, tall oat grass, wheatgrass and smooth brome.

August to November pasture production was generally similar from all test grass swards resulting from a large subterranean clover component mainly on the slope (Fig. 3). Although herbage dissections revealed marked differences in sown grass yields (Fig. 2), Black Mountain rye and ryegrass clearly outyielded other grasses since August. Upland brome outyielded the remaining grasses except tall oat grass. Cocksfoot, phalaris, wheatgrass and smooth brome yields were comparatively low at this time.

Over the dry summer period (Nov - March) growth rates of all grasses declined considerably and production was low. Black Mountain rye production was highest and outyielded most other grasses, except upland brome and cocksfoot. There was no growth of ryegrass or phalaris during this period.

Low summer grass production continued until late April rain (Fig. 1). Further mild temperatures (Table 1) helped improve production until the paddock was again grazed, commencing 1 June 1991. Black Mountain rye again outyielded all other test grasses during the autumn period followed closely by cocksfoot. Tall oat grass and phalaris outyielded the remaining test grasses. Black Mountain rye and cocksfoot yields were outstanding, providing large amounts of quality herbage. Smooth brome grass developed well during this period outyielding ryegrass and wheatgrass and matching production from upland brome. Ryegrass yielded least of all grasses tested during autumn 1991.

Digestibility

Chemical composition and digestibility criteria for the eight grasses trialled and Oranga lucerne from a nearby site are presented in Table 4.

Total nitrogen and crude protein levels varied widely between the grasses. Smooth brome and phalaris ranked highest and upland brome and ryegrass had the lowest values. The remaining grasses were intermediate. Essentially, the reverse applied to fibre content. Estimations of metabolisable energy and digestibility ranked phalaris, smooth brome and cocksfoot as high, upland brome and ryegrass as low and Black Mountain rye, tall oat grass, and wheatgrass were intermediate.

Discussion

Pasture production

Production measurements have shown differences in the seasonal growth patterns of the grasses trialled and this will affect their suitability for use in the hill and downland country of the region.

In comparison to the other test grasses the performance of Black Mountain rye was far superior. Black Mountain rye is a perennial grass with similar attributes to ryecorn (*Secale cereale*) (Oram 1987; Allan *et al.*, 1990) in that it has strong seedling vigour and cool season activity. The herbage growth of Black Mountain rye ranked best over all test grasses throughout the year and cool season growth was exceptional. Despite the very dry summer conditions Black Mountain rye outyielded cocksfoot by 33%, a species long recognised in the region for its suitability to the combination of hot dry summers and cold dry winters (Douglas, 1966, 1974). Kara cocksfoot is reputed to give a wider seasonal spread of pasture growth especially in the summer and autumn than other New Zealand cultivars in this region (Scott and Maunsell, 1986) although it is less productive in spring than Apanui (Rumball, 1982). The use of Kara in this trial reinforced these facts and lax rotational grazing with long spells aided its establishment. The lower yields in winter and spring probably reflected its intolerance to excessive drilling depth (Woodman *et al.*, 1990) and its slower establishment (Hume and Fraser 1985). Similarly, lower

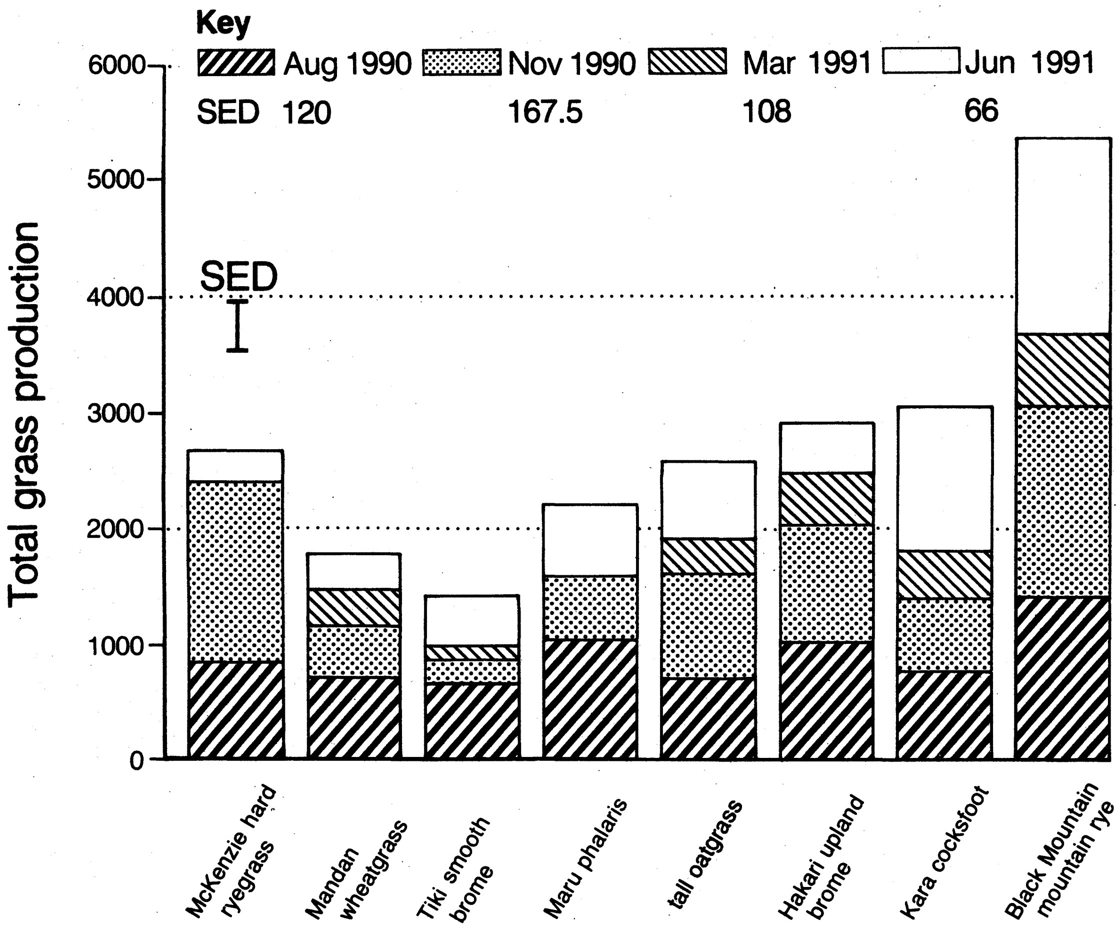

Figure 2. Seasonal grass production from Belfield Station on-farm trial during 1990/91 (kg DM/ha).

yields from smooth brome, wheatgrass and tall oat grass reflect their slow seedling shoot growth, the result of slow root development. Thus, hard frequent grazing of these grasses in particular must be avoided since this will deplete plant carbohydrate reserves (Bommer, 1966) and reduce plant rooting depth (Weinmann, 1948).

The cool seasonal growth patterns of these grasses generally agree with their reputed characteristics. For example, autumn yields of Kara cocksfoot, Maru phalaris, Hakari upland brome and Tiki smooth brome were similar to those reported elsewhere for the region (Scott and Maunsell, 1986) including the same rank order. Maru phalaris was dormant throughout the dry summer, however, its response to rainfall was rapid, an observation in agreement with Fraser (1982) and subsequent autumn yield and herbage quality was good, although stock acceptibility was poor at all grazings (McKenzie pers. comm.). The cool seasonal growth pattern of tall oat grass was most encouraging, equalling phalaris in autumn and outyielding it in both spring and summer. As expected, upland bome production was mainly restricted to spring and summer, however, the wider seasonal spread of smooth brome at this site was unexpected (Rumball, 1987). Nevertheless, its autumn growth can be considered a most valuable agronomic attribute in this environment. Wheatgrass grew slowly in all but the colder months a fact earlier recognised in the semi-arid regions of the South Island by Wills (1984).

Perennial ryegrasses remain a widely used component of improved grasslands in the sub-humid and semi-arid

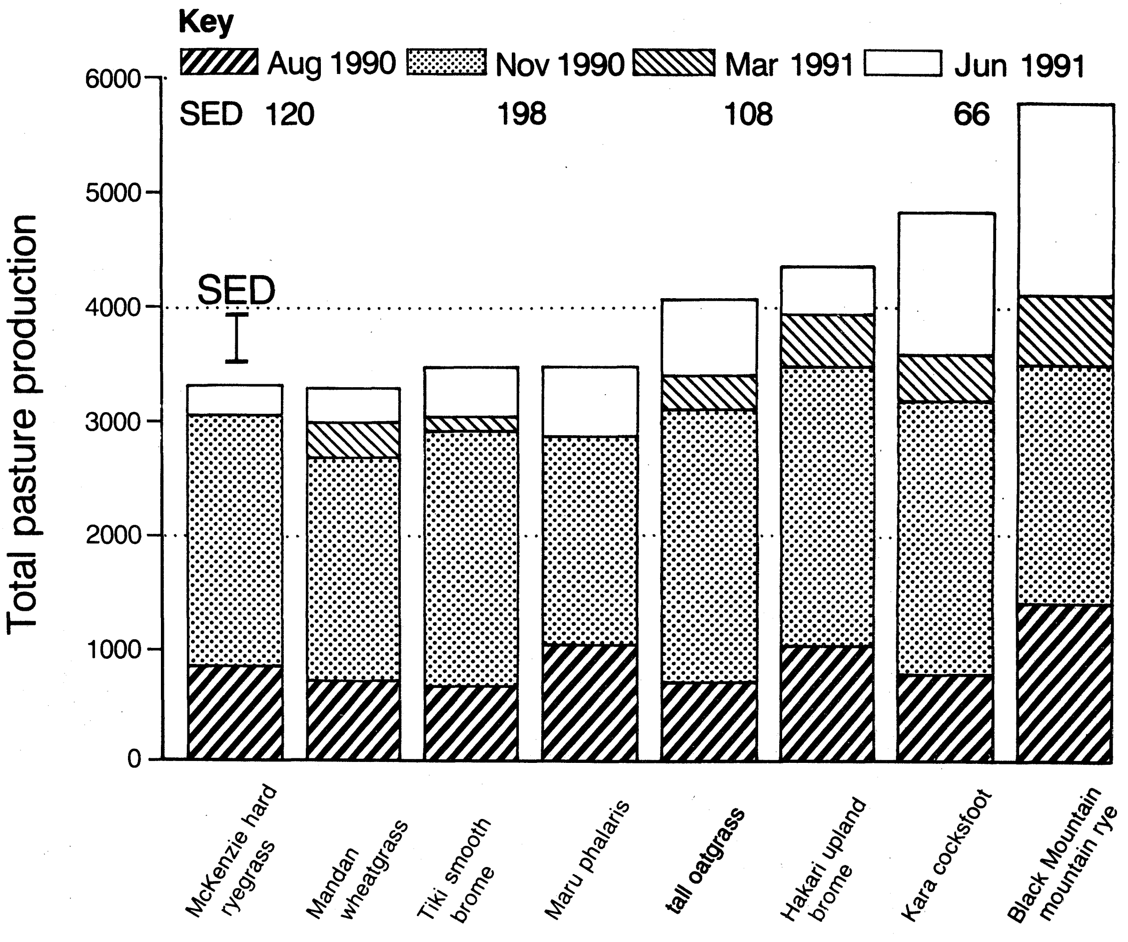

Figure 3. Seasonal pasture production from Belfield Station on-farm trial during 1990/91 (kg DM/ha).

Table 4. Chemical composition and digestibility of grasses and lucerne in June 1991.

	Total N (g/100 g DM)	Crude protein (g/100 g DM)	Fibre (g/100 g DM)	Metabolisable energy (MJ/kg DM)	Digestibility (%)
Maru phalaris	3.53	22.1	27.4	12.5	80.6
Black Mountain rye	3.19	19.9	29.1	11.9	76.8
Tiki smooth brome	3.55	22.2	29.2	12.2	78.7
Tall oat grass	3.09	19.3	30.0	11.7	75.5
Mandan wheatgrass	3.17	19.8	35.3	11.0	71.0
McKenzie hard ryegrass	2.42	15.1	35.6	10.3	66.4
Hakari upland brome	2.52	15.8	34.3	10.6	68.4
Kara cocksfoot	3.35	20.9	28.4	12.2	78.7
Oranga lucerne	3.80	23.8	25.7	13.0	83.9

regions of North Otago and South Canterbury and therefore warranted consideration in this trial. Local ecotype perennial ryegrasses have performed well within the region (Chapman *et al.*, 1989). A local ecotype high endophyte ryegrass with reputed high adaptation to this environment (cv. McKenzie hard ryegrass) was chosen for testing.

Generally, perennial ryegrass had poor seasonal spread of growth under the different environmental conditions within the trial site. After initial establishment, contribution from ryegrass to the annual yield was mainly from herbage grown in spring. McKenzie hard ryegrass was completely dormant in summer and had poor regrowth when soil moisture status improved in the autumn. In situations where very dry summer conditions are common the role of summer dormancy in promoting tiller bud survival and drought tolerance is well recognised (McWilliam, 1968). Indeed, virtual dormancy for example of Maru phalaris during hot dry summers has been considered a valuable characteristic, resulting in greater persistence through drought (Rumball, 1980; Hume and Fraser, 1985). However, without the deep rooting ability of phalaris to transport enough water during drought to keep shoot apices alive (McWilliam and Kramer, 1968) plant persistence and/or the ability to respond rapidly to rainfall will be poor.

Plant populations

On the flat, young ryegrass populations declined more (by 45%) than other grasses tested during the establishment season. This can be partly attributed to its intolerance to grass grub attack on these soils, unlike Black Mountain rye which rapidly established a vigourous root system able to tolerate grassgrub attack. Ryegrass plant persistence was poor during the summer on the sloping terrain exposed to the dry prevailing winds. McKenzie hard ryegrass therefore, appears poorly adapted in areas prone to grass grub and/or Argentine stem weevil attack and hot dry summers.

It is noteworthy, that overall the ryegrass population remained stable during the winter period. In contrast, other grass populations declined markedly over this period particularly on the more frost prone lower flat land. Thus, McKenzie hard ryegrass appears highly frost tolerant, an important agronomic requirement of pasture species especially at the seedling and young plant stage.

However, certain caution must be used when considering the establishment of these test grasses, since a significant population decline, especially from the higher populations may merely reflect the density-dependent 'self thin' effect to an equilibrium density above the minimum required for maximum production (Yoda *et al.*, 1963). In this trial there appears to be only a temporary advantage in sowing phalaris, wheatgrass and upland brome at higher seed rates than will give this density initially. The initial density obtained from Black Mountain rye, cocksfoot, tall oat grass and smooth brome may be closer to the minimum required for maximum production. Yet, differences between cultivars may influence the final density required for maximum production.

Plant populations of wheatgrass and phalaris increased significantly during the period November to June within the whole trial area. Smooth brome increased by 88% on the flat, stony area and 35% (not significant) on the terrace slopes. Phalaris plants occupied the within row spacing, whereas wheatgrass and smooth brome grass plants were confined to the drilled rows. Root inspection of these plants revealed that the reputed rhizomatous wheatgrass and smooth brome grasses (Rumball, 1987; Wills, 1984) had no rhizomes at this stage (June 1991) but phalaris had usually formed at least one rhizome approximately 10 cm long per plant with associated above ground leafy shoot. Thus increased phalaris plant populations probably resulted from newly formed rhizomatous shoots, while increased wheatgrass and smooth brome grass plants are attributable to recent emergence from seed which lay dormant during the autumn/winter. This agrees with reports from North America (Kilcher, 1961) which mention similar dormancy from 'rangeland' type grass species including wheatgrasses.

Grass/legume compatibility

The resident subterranean clover component of the ryegrass pasture sward was extremely low (Fig. 3). Of the grasses tested McKenzie hard ryegrass and Black Mountain rye, appear the least compatible with subterranean clover. This is probably due to their vigorous spring growth suppressing the legume component, resulting in less fixed-N and less available soil nitrogen for sown grass herbage production. However, red clover is the preferred legume to be sown with Black Mountain rye (Allan *et al.*, 1990), and cv. Redquin red clover has shown good promise as a compatible legume with Black Mountain rye in this trial. The compatibility of other test grasses with the resident legume base was good during these early stages, and indeed improvements in overall production compared to ryegrass and Black Mountain rye plots were obtained from all other test grasses (Fig. 3).

Chemical composition and digestibility

The digestibility values were comparable with those reported by Ulyatt *et al.* (1980) and Scott and Maunsell (1986) for the relevant species in autumn. Generally, total nitrogen and crude protein levels in the grasses were good in relation to the expected high levels in lucerne, and probably reflect adequate amounts of N fixed by the resident subterranean clover and available as soil nitrogen for grass growth at the site. The digestibility of the ryegrass and upland brome was lower, and smooth brome was higher than expected (Scott and Maunsell, 1986) and could relate to a modified seasonal growth pattern of these species in this particular environment. Noteworthy, tall oat grass, often reputed to have low acceptibity to stock had relatively high herbage quality and was well utilised by stock at all grazings.

Conclusions

In the semi-arid environment of the Hakataremea Valley, South Canterbury, the grasses tested displayed widely different seasonal growth patterns as well as their ability to tolerate harsh climatic conditions/pest attack. Although sustainable and ecologically sound pastoral systems need to be proven over more than a year or two, various species are beginning to exibit the agronomic characteristics considered essential as part of the seasonal grazing system sought by farmers in the region.

Black Mountain rye was the most productive grass during all seasons. Kara cocksfoot also showed wide seasonal spread with high production in autumn. Mandan wheatgrass growth was spread throughout early spring to late autumn but was relatively low yielding. Tall oat grass produced well mainly in the cool season. Hakari upland brome produced large amounts of spring and summer herbage, but was intolerant of grass grub attack in its second year. Tiki smooth brome established slowly and yielded best in the autumn. Maru phalaris production was the most seasonal, being dormant in the late spring and summer and providing good cool season growth, but was the least utilised by sheep. McKenzie hard ryegrass was outyielded only by Black Mountain rye during the spring, otherwise compared with other grasses tested seasonal spread of growth was poor, plant survival during summer was poor, and seasonal grazing acceptability and digestibility in June were low.

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