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Resident ryegrass in hill country pastures

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Abstract

The attributes of 1800 ryegrass plants removed from North Island hill country aredescribed and the implications for oversowing discussed. Morphology was varied but the mean of the population was prostrate and densely tillered, resulting in dense pastures under intensive grazing. Although morphology was not related to the site of plant origin, agronomic response to low nitrogen and moisture stress was. Plants from north-facing steep areas responded least to application of nitrogen or water indicating a low relative growth rate. A probable survival mechanism for moisture-stressed plants is reduced vegetative growth and increased seed set. Response to moisture stress was found to be heritable. In moderate-high fertility steep sites total ryegrass production has not increased after oversowing new cultivars. It is assumed that this is a reflection of the number of niches available for ryegrass exploitation. Our studies show that the strength of existing ryegrass is its genetic diversity and its ability to exploit the various niches present in hill country. The growth and expansion of these ryegrass populations should be actively encouraged. In niches below the optimum for rycgrass growth new species should be introduced.

Keywords hill country, perennial ryegrass, morphology, stress, genetics, oversowing, management

Introduction

Ryegrass has been an integral part of hill country pastures sincethefirstbushburnoversowings. Pastures that have not undergone any renovation for the last 50 years still have a large ryegrass component. An option for improving hill pasture productivity is to replace these resident ryegrass plants with new improved ryegrass cultivars.

These have been principally produced with some specific seasonal or special attribute in view, largely used on high fertility dairy farms, whereregularpasture renovation is required. None have been specifically bred for use in hill country, and little research has been undertaken to document the characteristics of resident hillryegrassnecessaryformakingimprovements (Forde & Suckling 1980; Wedderbum *et al.* 1989a, 1990).

This paper reviews the results of 5 years' work conducted at the Whatawhata Research Centre describing the attributes of ryegrass plants removed from old hill pastures and discusses the implications this information has to the pasture management decisions of the future.

Origin of Whatawhata Hill Ryegrass Collection

Astratifiedsamplingproceduretocoverawideecological range was devised to determine if distinct ryegrass populations relating to habitat had evolved. To this end, 1800 perennial ryegrass plants were removed in March 1986 from 60 microsites on North Island hill country

Table 1 Perennial ryegrass cultivars used for comparison with hill ryegrass plants.

Cultivar	Description
'Grasslands Ruanui'	Bred from plants collected in New Zealand.
'Grasslands Nui'	Bred from plants removed from a high fertility dairy pasture.
'Grasslands Ariki'	A Ruanul x Manawa cross for use on highly fertile soils. It contained high endophyte.
Ellett	Similar to 'Grasslands Nui'.
Yatsyn	Similar to 'Grasslands Nut'.
Droughtmaster	Bred from plants removed from old permanent pastures subjected to grass grub infestation and moisture stress in Hawkes Bay.
Takapau Persistor	Similar to Droughtmaster, but slightly later heading, more prostrate and with narrower leaves.

(i.e. 5 land classes x 2 farms x 6 regions). None of the 12 farms had been oversown for at least 20 years. Detailed site description is documented in Wedderbum *et al.* (1989a). Eachryegrass plant was maintained in a 15 cm diameter pot filled with sterilised soil in a common outdoor environment. Commercial cultivars were used for comparison (Table 1) throughout the study and maintained under the same conditions.

All morphologicalmeasurements on individual plants commenced in April 1986 and continued for one year: Tiller leaf dimensions, tiller number, endophyte status, date of heading, culm, spikelet and floret number and seed production. Detailed methodologies are cited in Tucker & Pengelly 1987.

Morphological description (Table 2)

All morphological measurements recorded for the hill collection were highly variable e.g. tiller leaf length ranged from 40-240 mm, heading date ranged from 2-40 days and culm numberranged from 10-90 (Wedderbum *et* al. 1989a). The variability present in commercial cultivars was not so great as the hill collection e.g. Ellett's tiller leaf length ranged from 110-210 mm, heading date ranged from 8-30 and culm number from 30-60. The mean of the hill collection was distinct from those commercial cultivars bred from plants removed from high fertility areas (Wedderbum *et al.* 1989a). Hill ryegrass plants were mostly prostrate in form with many short narrow tillers, and a potential for high seed production. Ellett, 'Grasslands Nui' and Yatsyn had semi-erect, few long, wide tillers, which head earlier than the hill collection and have less seed production potential. Commercial cultivars closer to the hillryegrass morphology were 'Grasslands Ruanui', 'Grasslands Ariki' , Droughtmaster and Takapau Persistor (Wedderbum *et al.* 1989a).

The presence of endophyte was determined by the technique of di Menna & Waller (1986) immediately after the plants were brought in from the field, Eighty-five percent of the collection contained endophyte but the concentration between plants was variable and was not related to site of origin (Wedderbum *et al.* 1989a). The high incidence of endophyte highlights its importance in maintaining persistence of the plants over all land classes.

Traits associated with seed production were related to specific sites of origin. Seed production potential was greatest in plants removed from north aspects i.e. north easy slopes 8186: south easy slopes 7581, SED 295 (Wedderbum *et* al. 1990). This phenomena may be linked to the regular summer moisture deficits experienced by north aspects. The presence of annual grasses and legumes on these sites also reflected the occurrence of periods of low moisture availability. Reseeding on these aspects would complement vegetative growth or in the event of plant death allow survival through re-establishment when moisture is sufficiently available. The diversity of plant types present within the hill ryegrass collection indicates that no single selection factor is acting to determine morphological characters. This confirmed the conclusions of Forde & Suckling (1980) for ryegrass removed from wet hill country. The range of phenotypes noted in this study and that of Forde & Suckling (1980) was similar to that described by Levy & Davies (1930) and Levy & Saxby (1932); these included erect, dense, leafy "true perennial type", semi-erect, dense tussock like plants with fine tillers and lax open erect types. The mean plant type of the collection, (prostrate and densely tillered) is in a form which is similar to that noted by Charles (1970) and which results in the maintenance of dense pastures. This plant form will help control ingression of weeds and maintain soil stability. The presence of many tillers is important for vegetative propagation under intense grazing management. The lack of persistence of 'Grasslands Nui' after 2 years in steep hill country was attributed to its erect and open growth habit resulting in plant damage during severe grazing (Chapman 1986).

Table 2 Morphological characters of commercial cultivars **and the** mean hill collection grown under a common environment. Tiller number, tiller leaf length (TLL). and tiller leaf width (TLW), heading date (Days after 28 October), culm number and seed production.

Commercial Cultivar	Tiller Number	TLL (mm)	TLW (mm)	Heading Date	Culm Number	Seed Production
'Grasslands Nui'	23	171	5.8	22	30	5397
Ellett	19	178	6.4	16	34	6507
Yatsyn	21	172	6.7	20	35	5768
'Grasslands Ruanui'	23	140	5.0	19	41	8414
'Grasslands Ariki'	37	141	4.9	27	42	6326
Droughtmaster	28	154	5.8	22	45	7808
Hill Collection	27	133	5.3	22	48	7561
SED	2.0	7.0	0.2	2	3	515

Agronomic characteristics

Two of the main environmental stresses acting on grasses in hill country are low soil nitrogen and low soil moisture. Since the collection was removed from diverse habitats ranging from high fertility night camps to north steep zones it was expected that genotypes tolerant to these stresses would be present. An experiment was established to test if agronomic response to these two stresses was related to site of origin (Wedderbum *et al.* 1990).

A soil bin technique was devised in an attempt to simulate a hill soil environment but which gave greater control over environmental variability (Wedderbum *et* al. 1989b). Three bins (7.9 m long x 1.1 m wide x 0.6 m deep) were constructed and a soil profile built up in each, using layers of hill subsoil and topsoil compacted to field bulk density. The hill ryegrass and standard cultivars were cloned and two tillers per individual plant transplanted at 5 cm spacing, This technique enabled controlled manipulation of soil fertility and development of simulated pure sward conditions while still allowing individual plant identification. The large soil volume allowed drying down to approximate field conditions and permitted plants to express their full rooting potential. Treatments were set to give two contrasts with nitrogen and water, i.e. adequate N and water versus low N and moisture stress. The experiment was initiated in July 1987 and was completed April 1988.

A significant interaction was identified between plant response and site of origin (Table 3). Plants removed from sites low in nitrogen (i.e. steep zones) had the least growth when nitrogen was applied (0.45 mg, compared to 0.48 mg on easy slopes SED 0.01) indicating that these plants had a low relative growth rate. Grime & Hunt (1975) reported that nutrient poor soils tended to contain a higher proportion of species of low relative growth than fertile soils, permitting the conservation of captured resources. Since no aboveground morphological measurements of the plants correlated well with response to nitrogen the mechanism may be root orientated or physiological (Wedderbum *et al.* 1990). Grime (1979) notes that for stress tolerators the most important responses to environmental variation are physiological rather than morphogenetic. During moisture stress plants from northern aspects wilted faster and had reduced tiller scores 2.0 versus 2.3 where 0 = all brown tillers and 4 = 100% green tillers at the end of the drought period (Wedderbum *et al.* 1990). Similar results have been reported previously for Italian, hybrid, and drought tolerant ryegrasses (Norris 1979; Norris & Thomas 1982). Plants from seasonal moisture stressed environments appear to adapt to moisture *stress* by reducing leaf area. They also demonstrate an overall low relative *growth* because they responded least when grown under a regular water supply (Wedderbum et *al.* 1990). A probable survival mechanism for moisture stressed plants is reduced vegetative growth and increased seed set. Plants which did well under low nitrogen also did well under moisture stress indicating there may be a root mechanism involved which requires further study.

From this hill ryegrass experiment three broad types of responses were identified:

A Plants which had low overall yield and a low response to stress alleviation.

Table 3 Response of ryegrass plants removed from differing hill country land classes to addition of N, zero N and moisture stress.

	Land Class (aspect . slope) (a)					
	N-e	N-s	S-e	S-s	Camp	SED
√dry weight (g) + N	0.48	0.45	0.47	0.44	0.46	0.01
- N	0.38	0.35	0.35	0.35	0.38	0.01
√dry weight (g) after relief of moisture stress	0.34	0.34	0.41	0.39	0.40	0.02
Wilt score (b)	·10.20	10.30	10.80	10.80	10.40	0.19
Tiller number (c)	2.00	2.10	2.30	2.30	2.30	0.10

(a) N = northern aspect; S = southern aspen; e = easy (10-25°) slope; s = steep (>30°) slope.
(b) Total of six recordings; range 1-5 where 1 = all brown leaves and 5 = green turgid leaves.
(c) 12 days after relief of moisture stress; range O-4 where 0 = all brown tillers and 4 = 100% green tillers.

B Plants which produced well in the absence of stress but poorly under stress.

C Plants which produced well under stress and also responded well to stress alleviation.

Type A plants will be of most benefit in chronically unproductive environments where a low rate of production can be expected.

Those ryegrasses bred for high fertility dairying environments are a good example of type B plants.

For hill pastures where environmental conditions are in a constant state of flux it is important that plants are capable of rapid recovery when stress is alleviated, i.e. type C. This process has advantages over annual type plants which require seed establishment for continued persistence.

Heritability of stress response

The diversity of plant response within hill ryegrass pastures may explain its ability to withstand wide fluctuations *in stress.* An *experiment* was conducted to test if responses to nitrogen and moisture stress were heritable. The bin technique was used with similar treatments applied to mother plants, progeny and standard cultivars (Wedderburn *et al.* 1992). Parent plants selected for high dry matter yields on relief of drought produced progeny which exceeded both the base hill country collection and the best commercial cultivars available. The heritabilities estimated (tiller number after drought h^2_2 0.66, dry weight after drought h^2_2 = 0.92; Table 4) indicate that it would be possible to synthesise a more drought-tolerant germplasm base from hill country selections. Because of its diverse origin such a base should possess sufficient genetic variability to allow for further progress.

Table 4 Estimates of heritability of agronomic traits calculated from parent-offspring regressions between groups (h^2_2). Standard errors of estimates given in parentheses.

Heritability of means over 6 replicates	
Attributes	h^2_2
T1	0.79 (.33)
DW1	0.66 (.21)
WSC	1.10 (.49)
T2	0.66 (.44)
DW2	0.92 (.35)

T1 = tiller number pre drought. DW1 = dry weight on addition of N, WSC = total wilt score, T2 = tiller number post drought. DW2 = dry weight after addition of water.

Practical implications for resident ryegrass

Hill country ryegrass populations are highly variable in phenotype and contain a range of plant responses to stress which are heritable. Our studies show that the strength of existing resident ryegrass populations is in its genetic diversity and its ability to exploit the various niches present in the hill environment. The growth and expansion of these ryegrass populations should be actively encouraged. This can be done by regular application of fertiliser and the correct grazing management (Wedderburn & Dodd 1991). Replacement with new cultivars which have not been bred specifically for this environment should only be contemplated in special circumstances, if at all.

Few studies have monitored the effect of oversowing grass into hill country that already contained a nucleus of ryegrass plants. Results from earlier oversowing studies (Suckling 1950; Forde & Suckling 1980) where ryegrass did not persist are confounded by the method of introduction which did not reduce competition of resident vegetation. Chapman (1986). however, introduced 'Grasslands Nui' into existing moderate fertility hill country with 7% resident ryegrass cover and although ryegrass levels initially rose, the effect had disappeared after 2 years. The hard grazing management imposed on the area had a detrimental effect on the erect and open growth form of Nui. Oversowing with Nui on steep east facing country of moderate fertility did not increase total or seasonal pasture production (Chapman 1986). Similarly when Ellett ryegrass was oversown into steep country of high fertility at Whatawhata Research Centre the ryegrass component did not increase (Webby *et al.* 1990). Since neither of these cultivars had been bred for hill country they could not have necessarily been expected to outperform resident species which are better adapted to the environment.

The inability of new ryegrass cultivars to alter total production at the moderate to high end of the fertility scale is a reflection of the number of niches which are available for ryegrass exploitation. If pastures have received regular topdressing and clover cover is widespread then ryegrass should be present. Replacing resident ryegrass with a new cultivar will fill existing niches only and therefore be of little benefit. Only if a new ryegrass cultivar is developed with specific traits which allow it to exploit not only existing niches but also those other niches below the optimum for resident ryegrass, will total production be raised. Where soil fertility has been increased but ryegrass is absent a mixture of current ryegrass cultivars should be sown to ensure genetic diversity, which will allow exploitation of many niches.

In steep areas where N level will always be low, greater increases in production will be achieved by adding different species rather than current ryegrass cultivars. At Whatawhata the greatest production benefit occurred when 'Grasslands Wana' cocksfoot was introduced into low producing sites such as inter-track zones, areas on which ryegrass and white clover do not readily establish (Webby *et al.* 1990).

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