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The Native and Low Input Grasses Network

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ABSTRACT

The Native and Low Input Grasses Network (NLIGN) is a collaborative project of NSW Agriculture, the University of New England, Agriculture Victoria, the Tasmanian Institute of Agricultural Research, the South Australian Research and Development Institute and Agriculture WA. It was established to evaluate the increasing number of grasses both of native and exotic origin which are being developed for low input pastures.

The NLIGN assembled 58 of the most promising grass populations and tested these across 8 sites, which ranged from the high rainfall permanent pasture zones of eastern Australia to drier mixed farming regions and the Mediterranean permanent pastures of South and Western Australia. Evaluation occurred under low input management similar to the ‘real world’. Several populations of wallaby grass, wheat grass, kangaroo grass and cocksfoot performed well in a number of locations, and 5 accessions were selected for further development. There were another 20 grasses that performed well at fewer sites, and these also deserve consideration.

Further research is necessary with these native and low-input grasses prior to cultivar release to develop establishment and seed production techniques and better understand their sward performance. Potential new cultivars that have been identified in this project could provide graziers with superior low-input grasses that will lead to more stable pastures and more sustainable animal production.

A view of the Native and Low Input Grass Network site located at Canberra, on the southern tablelands of NSW in May, 2000. 1.5 m square plots are shown, containing 36 plants of each test accession. White pegs indicate plants that have died.

EXECUTIVE SUMMARY

For a long time, many graziers have acknowledged the importance of native species to animal production in Australia. However, it was not until the major droughts and slump in pastoral commodity prices of the 1980's and 1990's that pasture researchers as a group began to appreciate the advantages of these plants. Many native grasses have good drought resistance and persist better under low fertiliser input than species of European origin (e.g. perennial ryegrass, phalaris) which are commonly sown in pastures in Australia. As a consequence, a number of projects have domesticated a range of native grasses, but until now there has been no framework to evaluate the across-site performance of new cultivars and selections.

The Native and Low Input Grasses Network (NLIGN), which is the subject of this report, was established following the recommendations of the Second Australasian Perennial Grass Workshop in 1995, to provide this testing framework. Collaborating partners in the project were NSW Agriculture (the project leader), University of New England, Department of Natural Resources and Environment, Victoria, Tasmanian Institute of Agricultural Research, South Australian Research and Development Institute and Agriculture Western Australia. While this was the first project to deal with native species on a nationwide basis, NLIGN also acknowledged that a number of exotic species (e.g. cocksfoot) are well adapted to many low input situations. Several of these species were therefore also evaluated within the project.

The NLIGN project also explicitly acknowledged the need for some pasture species evaluation to be undertaken under low input conditions. This recognises that much of Australia's commercial pasture production occurs under low input conditions and, for many producers, this would be seen as research moving one step closer to 'real world' conditions. The fact that all grass species in NLIGN were evaluated under the same low input conditions also meant that native species were not disadvantaged against exotic species, in comparison to previous 'high input' research.

The objectives of NLIGN were firstly, to assemble low-input grass populations that were worthy of evaluation; secondly, to establish experimental sites across southern Australia to evaluate these grass lines; and finally, to identify lines with the potential to be released as cultivars after further development.

Fifty-eight grass populations were assembled for testing, and 5 'industry standard' cultivars were used for comparison. It was necessary to multiply the seed of some populations prior to their evaluation and this was done in 1997, before the commencement of the multi-site testing in 1998. The development of a specific protocol to ensure uniformity of management and measurements in the experiment was also necessary prior to establishment. A key feature of protocol development and subsequent data analyses has been the input of NSW Agriculture Biometrical Staff. These biometricians are world leaders in the conduct and analysis of multi-site plant breeding experiments, and their input has been important to the success of the project.

Eight evaluation sites were established across the temperate pastoral zones of southern Australia, with 4 located in the higher rainfall permanent pasture districts of the southeast (Armidale, NSW, Canberra, ACT, Rutherglen, Victoria and Jericho in the Tasmanian Midlands). Two sites were in the drier, mixed-farming regions of south-east Australia (Trangie and Binya, NSW), and the last 2 sites were in the southern, Mediterranean, permanent pasture districts at Flaxley in the Adelaide Hills, SA and Kendenup (Albany district) in south–west WA.

Sites were established over winter and spring, 1998. Evaluation continued for 3 years and was terminated in late June 2001. All grasses were grown as individual, spaced plants and evaluated by measuring herbage production, plant survival, seedling recruitment and palatability to sheep. In the final analyses, herbage production and plant survival have been the most useful in determinants of merit of the grass populations. This was because the amount of seedling recruitment which was observed at any site was sometimes more determined by soil characteristics at a site rather than by the genotypes which were being tested, and palatability could not be measured at all sites due to the lack of herbage production in the period immediately before this measurement was to be undertaken.

Pasture Science has gained significantly from this project. For the first time we have robust information relating performance of a range of low-input native and exotic grasses across temperate Australia. Such questions as the importance of provenance in grass performance can be addressed with data collected in these experiments. The ‘low-input’ experimental methodology was successful in identifying populations which would perform well under low-fertility conditions. For example, grass production rankings changed over the duration of the experiments at Binya and Rutherglen, from those that could give a greater response to the initially higher soil fertility (e.g. some cocksfoots) to lines that performed better under very low fertility conditions (e.g. wallaby grasses, *Austrodanthonia* spp)).

This project takes the view that a grass must be both highly persistent and capable of high levels of herbage production to warrant further evaluation toward cultivar development. It is also preferable that the genotype has had a high level of performance in both of these attributes at more than one site. With this in view a number of populations deserve further evaluation and development. In the southeastern, high-rainfall permanent pasture zone these include the cocksfoot accessions 2024, 1795 and 1784 from Tasmanian collections, F066 from South Australia, and *Elymus scaber* 473, a selection from the LIGULE program. Grasses which deserve further development for the south-eastern, dry, mixed farming zone include *Themeda australis* (LIGULE 165) and Bunderra wallaby grass (*Austrodanthonia bipartita*), while for the Mediterranean zone Bunderra wallaby grass also clearly warrants further R & D.

It was often the case that a grass performed well at one site but not at another. We believe that such grasses should not yet be discarded at this stage of the plant improvement process, as some sites represent large zones in themselves (e.g. the Albany site was the only one in WA), and the potential benefits of commercialisation for each of these grasses mean that they warrant further evaluation. With this in view, a number of site collaborators nominated grass populations which performed well at their locations, and these are identified in the main body of the report.

None of the native grasses identified in this initial 3-year project are ready yet for release. Further research and development is required to improve establishment techniques, seed production and understand performance in a sward prior to commercialisation. A new project to achieve these goals is therefore being developed, and we expect that successful candidates from this process will be available for commercialisation as cultivars in 5 years. The Pastoral Industry will be the clear winner from these projects, as it will have available productive and persistent ‘low input’ grasses which will ensure more stable pastures and more sustainable animal production. This is particularly so in more difficult areas, which may have shallower, less-fertile soils, or where producers are unable to maintain adequate fertiliser inputs for pastures with exotic sown species.

CONTENTS

1. INTRODUCTION

Over the last decade there has developed substantial awareness of the major contribution that certain perennial grass species make to the sustainability of grazing systems (Whalley 1970; Lodge and Whalley 1989; Garden *et al.* 1996;). These species, which are of either native or exotic origin include, among others, representatives of the genera *Austrodanthonia*, *Microlaena*, *Dactylis* and *Elymus*, and are often referred to as "low input grasses". This term has been developed to contrast them to exotic species (e.g. perennial ryegrass and phalaris), which often fail to perform when stressed by environmental constraints such as drought, soil acidity and low fertility, which commonly occur in Australian grazing systems. Factors which have fostered this awareness include: (i) the poor performance of exotic, "high-input" grass species in droughts (Hutchinson 1992) in contrast to that of low input species (Rivelli *et al.* 2001), (ii) the declining contribution of "high input" grasses in situations where fertiliser application frequency has declined (Cook *et al.* 1978; Kemp and Dowling 1991; Garden *et al.* 2001) and, (iii) increased appreciation of the positive role that perennial grasses play in the sustainability of agricultural and pastoral systems (Johnston *et al.* 1999; Garden *et al.* 2001).

The National Pasture Improvement Coordinating Committee (NPICC) has established three programs to coordinate and develop the breeding and evaluation of temperate pasture species. One of these, the Australasian Grass Improvement Program (AGIP), convened a workshop in October 1995 on what have come to be known as 'alternative' or ' low input grasses' (Reid 1995). The workshop identified a number of priorities, one of which was to identify the range of low input grasses researchers across Australia were working on, and to develop a network of researchers and evaluation sites. Further workshops were held in June 1996 and August 1997 to develop procedures and protocols for setting up this network. Objectives of high priority emanating from these workshops included the development of cultivars adapted to infertile and acid soils, grazing tolerance (by sheep), drought tolerance and improved digestibility.

This project, which was supported by Meat & Livestock Australia (MLA) provided funding for the coordination, establishment and evaluation of low input grasses by the collaborators in the network. The project was entitled, “Native and Low Input Grasses Network (NLIGN) – Multi Site Testing” and the activities of this project (MLA code number TR045) are described in this Final Report.

2. OBJECTIVES

The broad objective developed by the NLIGN was by 30 June 2001 to have identified low input grass lines from within the NLIGN which were worth commercialising. This was to be achieved by:

(a) assembling and, where necessary, multiplying seed for field evaluation;

(b) establishing experimental sites across southern Australia to evaluate the low input grass lines; and,

(c) identifying genotypes with potential as cultivars for specific uses and environments.

The above objectives would be achieved in the initial three year evaluation phase, which began in 1998, and which tested genotypes for *persistence, production* and *palatability.* Other information which is necessary prior to cultivar release, eg sward evaluation, nutritive value, seed production, appropriate establishment techniques, would not be able to be undertaken during the initial three year field evaluation. However, after the first component of the project had been completed a number of genotypes are likely to have been identified which possess good agronomic adaptation. It would then be appropriate to seek further public support, while also engaging a commercial partner, so as to complete the research necessary prior to release and commercialisation of any new cultivar.

3. MATERIALS AND METHODS

3.1 Site selection, description and meteorological records

The project evaluated grass genotypes at 8 sites across 3 different ago-ecological zones of temperate Australia (Figure 3.1). The zones were:

- Eastern Australian permanent pasture (Armidale, NSW, Canberra, ACT, Rutherglen, Vic,

- Jericho, Tas)

- Eastern Australian mixed farming (Trangie and Binya, NSW)

- Mediterranean (Flaxley, SA, Albany, WA).

Sites chosen were typical of the local region to which experimental results were to have relevance. Sites were described as thoroughly as possible (Myers *et al.* 1974) to enhance interpretation of genotype response to the environment. As an important component of the "low input" concept involves tolerance to infertile soils and adaptation to low fertiliser input systems, a thorough characterisation of the soil at each site was undertaken.

The minimum climate data collected was daily rainfall. However, where possible daily minimum and maximum temperature and daily evaporation were collected, as these parameters allow an estimation of the intensity of drought and frost conditions which the test genotypes experienced.

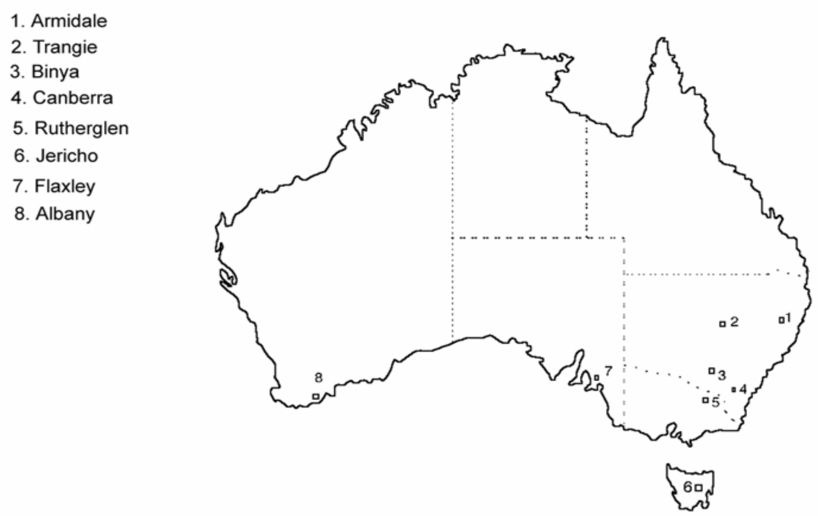


Figure 3.1. Location of sites in the Native & Low Input Grasses Evaluation Network

3.2 Grass genotypes evaluated

The complete list of genotypes evaluated is given in Tables 3.1 and 3.2. The testing sites covered such divergent regions that within each of these agro-ecological zones the number of similar grass entries tested was maximised so as to strengthen individual across-site analyses. The total number of genotypes evaluated in the experiments was 58. However, because of species characteristics, not all genotypes were tested at all sites, the minimum number being 32 and the maximum 36.

3.3 Plot establishment and husbandry

Prior to planting, soil samples (0-10 cm) were collected across each experimental site in a pattern defined by the project biometrical support team. After analysis of the samples, treatments were assigned in a controlled randomisation across the site to ensure that each treatment experienced similar soil conditions. Treatment randomisation across the plots was also controlled to ensure that no 2 treatments of the same species, which may be difficult to differentiate (e.g. cocksfoot), were likely to be neighbours.

Accessions were sown in 2 replications with standard cultivars interspersed across the experiment. Each plot comprised 36 plants of the test grass in a 6 x 6 plant arrangement. Spacing between individual plants in a plot was 0.3 m, resulting in a plot size of 1.5 m square. A gap of ca. 60 cm was left between plots. This was kept weed-free and plant invasion from one plot into its neighbours was kept to a minimum.

Table 3.1: Introduced species and accessions evaluated in the NLIGN project (standard cultivars shown in bold)

Entry	Species and accession	Originating agency	Eastern Australian permanent pasture zone				Mixed farming zone		Mediterranean zone	
			Armidale	Canberra	Rutherglen	Jericho	Binya	Trangie	Flaxley	Albany
1	***Dactylis glomerata* cv. Currie**		✓	✓	✓	✓	✓	✓	✓	✓
2	***Phalaris aquatica* cv. Landmaster**		✓	✓	✓	✓			✓	✓
3	***Eragrostis curvula* cv. Consol**		✓	✓	✓		✓	✓	✓	✓
8	D. glomerata (2024)	TIAR	✓	✓	✓	✓	✓	✓	✓	✓
9	D. glomerata (1795)	TIAR	✓	✓	✓	✓	✓	✓	✓	✓
10	D. glomerata (1703)	TIAR	✓	✓	✓	✓	✓	✓	✓	✓
11	D. glomerata (1784)	TIAR	✓	✓	✓	✓	✓	✓	✓	✓
12	D. glomerata (1715)	TIAR			✓	✓	✓			
13	D. glomerata (2011)	TIAR		✓		✓				
14	D. glomerata (13901)	DNRE, Vic	✓	✓	✓					
15	D. glomerata (13860)	DNRE, Vic					✓			
16	D. glomerata (13915)	DNRE, Vic					✓	✓		
17	D. glomerata (13946)	DNRE, Vic					✓			
18	D. glomerata (13880)	DNRE, Vic					✓			
19	D. glomerata (13932)	DNRE, Vic					✓	✓		
20	D. glomerata (13942)	DNRE, Vic					✓			
21	D. glomerata (13939)	DNRE, Vic				✓			✓	✓
22	D. glomerata (F066)	SARDI	✓	✓	✓	✓	✓	✓	✓	✓
23	D. glomerata (F083)	SARDI	✓	✓	✓			✓	✓	✓
24	D. glomerata (F146)	SARDI	✓	✓	✓	✓			✓	✓
25	*Festuca ovina* (829)	TIAR				✓			✓	✓
26	*F. idahoensis* (799)	TIAR				✓				
27	*Bromus biebersteinii* (27)	TIAR				✓				✓
28	*Elymus trachycaulus* (1143)	TIAR				✓			✓	✓
29	D. glomerata (P137)	SARDI					✓		✓	✓
30	D. glomerata (S267)	SARDI							✓	
55	*D. glomerata* cv. Kasbah						✓	✓		
56	*Bromus macranthos* (36)	TIAR								✓
58	*Bromus mango* (2048)	TIAR								✓
59	*F. arundinacea* cv. Au Triumph									✓
61	*Bromus mango* (1424)	TIAR								✓
62	Phalaris hybrid (AT96)	CSIRO		✓						
63	*D. glomerata* cv. Porto					✓				

Table 3.2: Native species and accessions evaluated in the NLIGN project (standard cultivars shown in bold)

Entry	Species and accession	Originating agency	Eastern Australian permanent pasture zone				Mixed farming zone		Mediterranean zone	
			Armidale	Canberra	Rutherglen	Jericho	Binya	Trangie	Flaxley	Albany
4	***Austrodanthonia richardsonii* cv. Taranna**	NSW Ag	✓	✓	✓	✓	✓	✓	✓	✓
5	***A. bipartita* cv. Bunderra**	NSW Ag	✓	✓	✓	✓	✓	✓	✓	✓
6	***Microlaena stipoides* cv. Wakefield**	UNE	✓	✓	✓	✓	✓	✓	✓	✓
7	***M. stipoides* cv. Shannon**	UNE	✓	✓	✓	✓	✓	✓	✓	✓
31	*A. duttoniana*	NSW Ag	✓	✓						
32	*A. racemosa*	NSW Ag	✓	✓	✓	✓		✓		
33	*A. caespitosa* (Dc1)	NSW Ag	✓	✓	✓	✓	✓	✓	✓	✓
34	*A. fulva*	NSW Ag		✓	✓	✓				
35	*A. pilosa* (Dp1)	NSW Ag		✓						
36	*A. pilosa* (2404)	TIAR	✓	✓		✓				
37	*A. caespitosa* (2407)	TIAR	✓	✓	✓	✓	✓	✓	✓	✓
38	*A. fulva* (Lig179)	LIGULE	✓	✓	✓	✓			✓	✓
39	*M. stipoides* (2402)	TIAR	✓	✓	✓	✓		✓	✓	✓
40	*M. stipoides* (Lig183)	LIGULE	✓	✓	✓	✓				
41	*M. stipoides* (Ms1)	NSW Ag		✓		✓			✓	✓
42	*Elymus scaber* (Es1)	NSW Ag	✓	✓	✓	✓	✓	✓	✓	✓
43	*E. scaber* (Lig473)	LIGULE	✓	✓	✓	✓	✓	✓	✓	✓
45	*Astrebla pectinata*	NSW Ag					✓	✓		
46	*Astrebla lappacea*	NSW Ag						✓		
47	*Bothriochloa macra*	LIGULE	✓	✓	✓	✓	✓	✓	✓	✓
48	*Chloris truncata* (Lig547)	LIGULE	✓	✓	✓	✓	✓	✓	✓	✓
49	*Themeda australis* (Lig165)	LIGULE	✓	✓	✓	✓	✓	✓	✓	✓
50	*T. australis* (2406)	TIAR				✓				
51	*Enteropogon acicularis* (Lig602)	LIGULE	✓	✓	✓		✓	✓	✓	✓
52	*Dichanthium sericeum*	NSW Ag	✓	✓	✓		✓	✓	✓	✓
53	*Paspalidium jubiflorum*	NSW Ag	✓		✓		✓	✓	✓	
54	*P. constrictum*	NSW Ag	✓		✓		✓	✓		✓
57	*E. scaber* (2405)	TIAR				✓				
60	*M. stipoides* (Ms2)	NSW Ag		✓						

An attempt was made to achieve a robust, uniform plant stand, with minimal differences between lines. Due to the slow establishment of native grasses, treatments were established in the field as transplanted seedlings on weed mat. Prior to transplanting, plants were grown in a glasshouse by sowing seed into “speedling trays” or “Hyco® pot trays” in a potting mix of 33% sand, 33% peat and 33% vermiculite. Nutrients were applied in solution using Thrive® or Aquasol®. Seed of all treatments (both C_3 & C_4 species) was sown concurrently. C_3 grasses were kept in the glasshouse for at least 6 weeks so they were big enough to be transplanted to the field. C_4 grasses were transplanted after the danger of frost had past. As these plants were held in the glasshouse for some time, a holding system which allowed air-pruning of roots was used. Clipping of the leaves of these plants while in the glasshouse was sometimes necessary.

Plants which failed to survive transplanting were replaced to ensure valid evaluation of all lines. The location of each transplanted seedling was marked using a method (e.g. plastic labels driven into ground, coloured nails in ground) which designated the position of the transplants for the duration of the experiment. When plots were fully established and test plants were unlikely to be smothered by weeds, the weedmat was removed.

Average district practice with respect to fertilisation for low input pastures applied. Fertiliser types, rates and time of application were noted. Plant protection was kept to a minimum although if, for example, a plague of grasshoppers threatened to destroy the whole experiment, protection measures were applied to save it. In the event that one treatment genotype was invading a neighbouring treatment, the invader was weeded out. Notes were made on each occasion (e.g. extent of invasion) when such weeding occurred. Irrigation could be applied to aid survival over the first summer, and where extremely severe drought threatened the whole experiment. In the latter situation, it was noted whether there were any genotypic differences in susceptibility to the stress inducing factor.

As not all investigators were able to arrange grazing of their sites, plots at all sites were mown off to a height of 4 cm. after each forage harvest. The plots were only grazed at the end of the experiment for an assessment of palatability. In exceptional circumstances (e.g. where a dense matted sward which needed to be broken up had developed, animals were permitted onto the plots). However, such grazing only occurred for as short a time as necessary.

3.4 Measurements

The major emphasis was on the collection of data on herbage production, persistence and palatability. The data was required to have an objective, quantitative nature amenable to statistical analysis. The availability of such data made it possible for the project to make confident assertions about the performance of genotypes, to facilitate cultivar commercialisation and development of recommendations for use by graziers.

3.4.1 Production

A minimum of three forage harvests per year were taken for determination of yield. All test accessions were harvested at the same time. The timing of harvests was:

(a) immediately prior to flowering of the earliest flowering accession in spring;

(b) after the latest flowering accession had shed ripe seed in summer; and,

(c) in mid winter

Plants were harvested at other times if occurred. As far as possible, timing of harvests was designed to avoid favouring some genotypes over others.

Forage production was determined solely by individual clipping of the 16 original plants in the centre of each plot (i.e. the outside row of plants was not used). Hand clippers were used and cutting followed the contour of the plant with the maximum cutting height over the centre of the crown being 4 cm. Where horizontal plant parts at the edge of the plant were present, these were cut off with blades held at an angle of 45 deg. Recruiting seedlings were not harvested. Harvested material was placed in a dehydrator until constant weight was achieved. Yield was presented as g/plant (mean of 16 plants, or the number of plants remaining). It was not feasible to present yield as kg/ha given the widely varying morphology of the test species.

After harvesting (and other measurements performed at this time), remaining juvenile plants and plants in the outer buffer rows were mown off to a height of 4 cm. All cut material was removed from plots.

3.4.2 Persistence

The different grass species tested in these experiments may “persist” by one or a combination of the following mechanisms:

- long term survival of the original transplanted individuals;
- on-going recruitment of seedlings to overcome the loss of original plants.

Therefore, once the weedmat had been removed, it was necessary to undertake separate observations to evaluate the relative importance of each of the above mechanisms. Persistence was measured twice yearly, at the end of May and end of August.

(a) **Survival of original plants**

The number of individuals surviving was recorded in relation to the number originally planted in the test area (16). Original plants were marked to ensure that they could continue to be identified.

(b) **Seedling recruitment (Frequency)**

A fixed quadrat of dimensions 0.9 x 0.9 m, containing 81 squares each of 10 x 10 cm was used. This quadrat covered the 16 original sampled plants of each plot, all of which were surrounded by “border” plants. *None of these “original” plants were counted in this observation.* Each square was assessed for presence or absence of a seedling crown of the test genotype. If a seedling of the test species was present within a plot of that same species, it was assumed that the seedling’s genotype was identical with the parent. A square with a crown was marked as "1" and without as "0". With this system it was possible, depending upon location, for a single plant to be counted in four different squares. Also, if more than one seedling was present in a square, it was only scored as 1. The data were presented as the sum of all the 1's and converted to frequency (%).

3.4.3 Leafiness

Leafiness was assessed 3 times annually immediately prior to harvesting, with attention being directed only to the leaf blade, not the leaf sheath. A continuous scale was used with zero signifying “no leaf” and 100, “only leaf”.

3.4.4 Habit

Habit was measured each Spring to coincide with a time when a substantial amount of plant matter was present. A continuous rating scale was used, with zero equal to “completely prostrate” and 100 equal to “completely erect”.

3.4.5 Damage

Frost, drought, insect or disease damage were noted.

3.4.6 Foliage and inflorescence colour

This was a voluntary qualitative assessment and was measured immediately prior to each of the three major harvests. Obvious differences in colour of foliage and inflorescences among species and among lines within species were described.

3.4.7 Palatability/Animal preference

This was assessed only once, in the autumn immediately before termination of the experiment. The plots were "crash-grazed" with a stocking rate of ca. 100 sheep/ha. Assessments of grazing intensity on the plots continued for as long as possible, bearing in mind ethical responsibilities associated with welfare of the sheep. Assessments occurred on days 1, 3 and 5. A continuous scale was used for recording with zero equal to "untouched" and 100 being "eaten off to ground level". Due to very dry conditions and absence of herbage prior to termination of the experiments, it was only possible to undertake palatability assessments at Armidale, Rutherglen and Flaxley. Means of palatability scores are presented for these 3 sites.

3.4.8 Remarks

Records were made of, for example, record excessive wilting of any genotype, difficulties with rating an attribute, etc.

3.5 Statistical analysis

3.5.1 Production

The natural logarithm (plus 1) of herbage yield data (g/plant) for each harvest at each site was modelled using spatial analysis. Each analysis involved fitting a linear mixed model which included design factors, the modelling of local stationary trend and the inclusion, where appropriate, of linear column, linear row, column effects, row effects and covariates. These models were fitted using the REML option of Genstat Release 5 ver.4.1. It was necessary to perform separate analyses for the C_4 species from the C_3, at the end-of-summer harvest of 2000/01 at Binya.

3.5.2 Persistence

Analyses of the plant population at the end of the experiment (survival of original transplanted seedlings) required a logit transformation prior to analysis using ANOVA. Frequency of populations of seedlings which established from seed which fell from original transplants was recorded and mean frequencies (%) presented.

3.5.3 Across-site analyses

Across-site analyses were undertaken using means from herbage yields, spatial analyses and means from final plant survival analyses. When analysing the group with 4 sites (Eastern Australian permanent pasture group) principle component analyses (PCA) were undertaken with results presented in biplot format (Gabriel 1971). For the 2 groups which each contained 2 sites (Eastern Australian mixed farming; Mediterranean) the means of one site were simply plotted against the means for the other site, with the graph being then divided into 4 quadrants. An entry which performed well at both sites using this method would be located in the top right hand quadrant. Means used in both of these types of presentations were either the modelled output from spatial analyses, ANOVA, or where this was not possible due to the need for transformation, raw treatment means.

4. SITE REPORTS

4.1 Armidale, NSW

(RDB Whalley, University of New England)

4.1.1 Site description

The site was used for grazing (both sheep and cattle) prior to about 1973 when two crops of potatoes were grown. It then reverted to grazing with cattle at about 7 DSE/ha and had been grazed more or less continuously until the experiment was established. Superphosphate was applied about three times at 100 kg/ha during the 1970s and 1980s but the site has not been fertilised since then. This type of land use history is common for native pastures in the district.

The dominant pasture species present at the time of the grass establishment were *Bothriochloa macra, Sporobolus creber, Paspalum dilatatum* and *Austrodanthonia racemosa* with patches of *Chloris truncata* and *Panicum effusum*. The legume component varied from year to year and included *Trifolium repens, T. glomeratum* and *Medicago polymorpha.* Annual grasses such as *Vulpia myuros, V. bromoides* and *Bromus racemosus* were common in most winters and annual and perennial forbs such as *Cirsium vulgare* and *Hypochoeris radicata* were common from time to time.

Other characteristics of the site are described in Table 4.1.1., and rainfall received at the site in Table 4.1.2.

Table 4.1.1: Characteristics of the Armidale site (according to the methods of Myers *et al*. 1974 and Northcote 1979).

Parent rock	D	Exchangeable Al (cmol/kg)	0.04
Aspect	S	Exchangeable Mn (cmol/kg)	0.09
Slope	L	Cation exchange capacity (cmol/kg)	6.06
Surface soil texture	L	Soil Organic Carbon (%)	1.90
Depth of surface soil	A	Total N (%)	0.16
Water relations	B	Available P (Olsen, mg/kg)	5.0
Soil pH	4.97	Electrical conductivity (dS/m)	0.07
Exchangeable Ca (cmol/kg)	3.84	Soil horizon depth; A_1 (cm)	0-10
Exchangeable Mg (cmol/kg)	1.54	Soil horizon depth; A_2 cm)	10-20
Exchangeable K (cmol/kg)	0.49	Soil horizon depth; B (cm)	20-70
Exchangeable Na (cmol/kg)	0.07	Northcote soil classification	Dr3.23

Table 4.1.2: Monthly rainfall recordings at the Armidale site from July, 1998 until May, 2001 (long-term average annual rainfall at Armidale is 790 mm).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998							124	122	115	79	41	47	
1999	91	89	140	70	16	39	54	40	56	151	117	71	931
2000	46	43	126	27	39	6.5	41	45	25	84	160	67	707
2001	117	83	144	33	79								

4.1.2 Site preparation and seedling production

The fence was erected and the weed matting laid in April, 1998 following spraying twice with Roundup® to kill the existing vegetation. Seeds of most species were sown in speedling trays (1 seed per cell) in a mixture of peatmoss, sand and vermiculite (1:1:1) on 23/4/98 in a heated glasshouse at the University of New England. Some resowing occurred during the first week in May for those species in which the germination was poor. The seedlings of the C_3 species were moved on to benches outside the glasshouse for frost hardening in late June-early July while the C_4 species were left inside.

4.1.3 Field planting

C_3 species were planted in the field commencing on 25/7/98 in holes burned in the weed matting, into a saturated soil profile. Unfortunately, rain and high winds interrupted planting and then there were severe frosts (-7°C screen temperature) for several nights. Many of the seedlings were damaged by the frosts. *Paspalidium constrictum* gave poor germination and was contaminated with seed of *P. jubiflorum.* It was resown twice, on 8/8/98 and 22/8/98. The seedling numbers were short and the buffer row round the outside of the plot was incomplete for both replications. *Phalaris coerulescens* was replaced by cocksfoot (F146) sown on 5/12/98.

C_4 species were planted out on the 17-18/10/98 and, again, the planting was followed several days later by several mild frosts. Some of the seedlings were damaged, but only a few were killed.

Seedling deaths were replaced as required several times throughout the summer with the final replacement and planting out of cocksfoot F146 occurring on 8/5/99. The number of surviving seedlings of the C_3 species was counted on 16/8/98 to assess the frost susceptibility of the seedlings of the different lines. The weed matting was removed on

23/5/99 and the plants were harvested on 26/10/99, 7/4/00, 10/7/00, 12/10/00 and 17/4/01. Harvests sometimes extended over several days. Final seedling frequency was measured on 24/5/01.

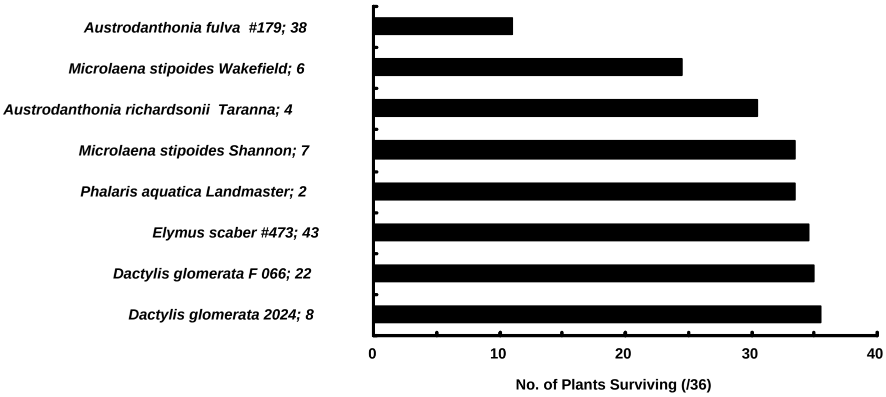
4.1.4 Grass performance

Thirty two different species and accessions were included in the experiment and, on the basis of their overall performance at Armidale, 11 were chosen as having the best potential for future development. These included nine C_3 (two species of *Austrodanthonia*, *Elymus scaber*, three accessions of cocksfoot, two accessions of *Microlaena stipoides* and Landmaster phalaris) and two C_4 (one accession each of Consol lovegrass and *Themeda australis*). Data will be presented only for these species and accessions in the remainder of this report.

(a) Frost damage

In general, the frost damage to C_3 plants was greatest in the different *Austrodanthonia* species and lines, with *A. fulva* being the most susceptible of all the species and accessions in the experiment (Figure 4.1.1).

Fig. 4.1.1: Mean number of C_3 plants surviving (out of 36) two weeks after severe frosts during planting out at Armidale. (LSD between lines is 8.4, *P*=0.05).



(b) Herbage production

A very good spring followed the planting out of the seedlings in 1998 (Table 4.1.2) and the plants grew extremely well and flowered and seeded prolifically during the late spring and summer. Adequate rainfall occurred during the winter and spring following removal of the weed matting in May, 1999, and the C_3 entries produced significantly more ($P<0.05$) dry matter than the two C_4 entries (Consol lovegrass and Themeda australis Lig165) (Table 4.1.3). The winter of 2000 was relatively dry and there was no significant difference in dry matter production between the two C_4 species and the better C_3 entries. The latter part of January and February 2001 were hot and dry and significant plant deaths occurred in many of the *Austrodanthonia* and cocksfoot accessions. Those plants that survived did not respond well to the rain in March 2001 and, so, the herbage mass of these entries at the April harvest was markedly lower than that in 2000, with the notable exceptions of Consol lovegrass, *T. australis* (Lig165) and Wakefield microlaena.

The production of most accessions generally decreased throughout the experiment with the notable exception of *T. australis* (Lig165). In general terms, the annual production of the C_3 and C_4 entries was not markedly different although there were major differences in their seasonal growth patterns.

Table 4.1.3: Herbage mass (g/plant) for five harvests at Armidale together with the total herbage mass summed over all harvests for selected species and accessions. Values within a column with different superscripts are significantly different ($P<0.05$).

Species and accession	**Entry No.**	**Oct-99**	**Apr-00**	**Jul-00**	**Oct-00**	**Apr-01**	**Total**
		g/plant					
Consol lovegrass	3	4.76^{e}	17.26	3.35^{a}	2.34^{ab}	14.03^{ab}	41.75
Landmaster phalaris	2	11.30^{ab}	13.33	2.28^{abc}	2.75^{a}	3.92^{bc}	33.58
Cocksfoot (F066)	22	14.16^{ab}	11.97	2.56^{abc}	2.54^{a}	1.70^{c}	32.92
E. scaber (Lig473)	43	15.72^{ab}	10.43	1.24^{abcd}	1.11^{abc}	3.90^{abc}	32.39
Cocksfoot (2024)	8	10.78^{ab}	14.29	3.22^{ab}	1.45^{cd}	1.86^{abc}	31.60
A. fulva (Lig179)	38	12.58^{abc}	10.23	0.73^{cd}	0.82^{bcd}	1.79^{c}	26.15
T. australis (Lig165)	49	1.76^{f}	7.84	1.76^{abcd}	0.71^{cd}	12.66^{a}	24.74
Cocksfoot (F146)	24	5.19^{cde}	9.57	1.77^{bcd}	1.61^{abc}	5.59^{abc}	23.74
Taranna wallaby grass	4	7.69^{bcd}	8.26	0.48^{d}	0.55^{cd}	2.83^{c}	19.80
Wakefield microlaena	6	4.30^{de}	8.54	0.66^{cd}	0.38^{d}	5.61^{abc}	19.50
Shannon microlaena	7	4.96^{cde}	7.24	0.77^{bcd}	0.47^{cd}	3.45^{abc}	16.89

(c) **Persistence**

The accessions included in this report were partly chosen with respect to their ability to persist either by the original plants surviving or by seedling recruitment. Apart from a few deaths soon after the weed matting was removed, the survival of the plants in the accessions selected for this report was high (Table 4.1.4). In some cases, a high frequency of seedlings was also recorded (Table 4.1.4), indicating that some accessions also have the ability to reproduce under the conditions imposed by this experiment. Accessions in this group included Wakefield and Shannon microlaena and *Elymus scaber* (Lig473). A second group was those where the survival of the original plants was high but few seedlings became established within the plots (Consol lovegrass and *T. australis* Lig165).

Table 4.1.4: Plant survival, seedling frequency and palatability scores of selected accessions at Armidale.

Species and accessions	**Entry No.**	**Surviving plants**^{A}		**Seedling frequency (%)**	**Palatability score (0-100)**		
		Oct-99	**Apr-01**	**May-01**	**30/5/01**	**31/5/01**	**4/6/01**
Shannon microlaena	7	16	16	75.9	64.2	90.6	100
E. scaber (Lig473)	43	16	13.1	57.4	42.9	66.1	100
Wakefield microlaena	6	16	15.6	41.4	46.9	78.0	100
A. fulva (Lig179)	38	16	15.6	33.3	60.6	83.5	100
Cocksfoot (2024)	8	16	13.1	32.7	85.4	94.5	100
Landmaster phalaris	2	16	14.5	22.2	77.6	95.3	100
Taranna wallaby grass	4	15.5	12.8	17.3	61.4	71.3	76.0
Cocksfoot (F066)	22	16	13.1	4.9	76.4	89.8	100
Themeda australis (Lig165)	49	12.0	11.3	3.7	84.3	91.7	100
Cocksfoot (F146)	24	16	11.6	3.1	75.6	94.5	100
Consol lovegrass	3	14.5	13.7	0.6	61.8	85.8	100

[A] Original total 16

(d) **Palatability**

The relative palatability of the entries was tested about six weeks after the final harvest. The weather was warm during this period and regrowth was apparent in all but three entries (all C_4 species). Six Merino weathers were introduced into the 20 m x 20 m experimental area on the 30th May, 2001 at 9.00 am and the amount of each accession eaten was scored at 4.30 pm on the same day. The accessions were scored again 24 hr later and again two days after the sheep had been removed at about 9.00 am on the 2nd of June. No visible growth had occurred between the time the sheep were removed and the final assessment. There were no marked differences in palatability among the species and accessions included in this report (Table 4.1.4).

4.1.5 Discussion

Persistence either by survival of the original plants or by population turnover is a critical attribute for a forage grass in sown pastures because of the high costs of establishment. Therefore, in the selection of the entries for inclusion in this report, persistence of the population as well as maintenance of yield over the life of the experiment were the attributes given the highest weighting. Seed is already commercially available for three of the 32 entries in the experiment. These are Landmaster phalaris, Currie cocksfoot and Consol lovegrass. Of these, Currie cocksfoot had poor persistence and so was not included in the final 11. Another three entries have been registered under Plant Breeders Rights (Taranna wallaby grass, Shannon and Wakefield microlaena), and commercial seed production is under way but not yet available. The remaining six entries compare very favourably in their performance with the commercially available cultivars. Provided the results for the Armidale site are comparable with those of other sites with a similar environment, then further information about the seed production and field establishment techniques for these lines is of the highest priority in order to capitalise on the results of this project.

4.2 Canberra, ACT

(DL Garden, C Shields, NSW Agriculture)

4.2.1 Environment and establishment

The Canberra site is located at Sutton, NSW, 30 km north of Canberra. The soil is a shallow red podzolic based on shale which has a low pH and available P (Table 4.2.1). Low pH continues to 50 cm depth (data not presented), and the site is a difficult one for many introduced species. Plants were transplanted into the field in August (C_3) and October (C_4) 1998. Some plants were replaced in 1998 due to damage from grubs, but weed mat was removed in December 1998 and the first sampling occurred in March 1999.

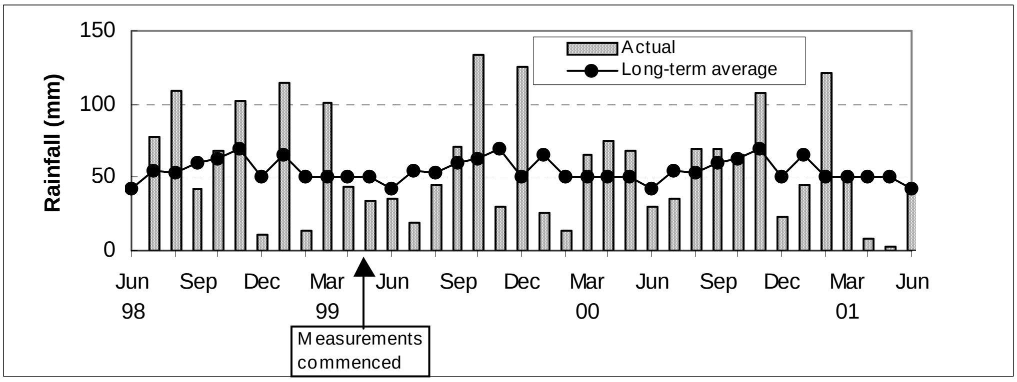
Table 4.2.1: Soil chemical data at the Sutton site before the experiment was established in 1998.

	pH ($CaCl_2$)	**Olsen P (mg/kg)**	**S (%)**	**N (%)**	**C (%)**	**EC (dS/cm)**	
0-10 cm	4.2	8	0.29	0.32	4.18	0.13	
10-20 cm	4.3						
	Cations (meq/100g)						
	K	**Ca**	**Mg**	**Al**	**Na**	**ECEC**	**% Al[A]**
0-10 cm	0.37	2.31	1.09	0.88	0.10	4.75	18.5
10-20 cm	0.18	1.33	0.96	1.34	0.05	4.19	32.1

[A] Percent of total cations

Rainfall and temperatures at the site are shown in Figure 4.2.1. Good rain was received following planting in spring 1998, allowing good establishment and growth of transplants. Normal dry periods have occurred over summer/autumn, but winter/spring rains have been average to above average each year, allowing good growth and survival of plants. However, a particularly hot and dry period over December/January 2000/2001 resulted in the death of plants of some lines, affecting plant survival results dramatically. Frosts in winter have caused mortality of several C_4 plants, particularly of their recruiting seedlings.

Figure 4.2.1: Monthly rainfall compared to the long-term average at the experimental site at Sutton, NSW (average annual total 660 mm).



4.2.2 Grass performance

(a) Herbage production

Plants were sampled on 8 occasions, although only data for the 6 occasions from winter 1999 to summer 2000/2001 are presented here. It is unrealistic to adequately describe the performance of all 36 lines. Therefore, only data on those that were ranked consistently in the top 10 at each sampling are presented (Table 4.2.2). Eleven lines were ranked in the top 10 at 3 or more samplings, and a further six at 2 samplings. The most consistently productive species were 3 of the cocksfoot lines (cv. Currie, selection 2024 from Tasmania, selection F083 from South Australia) and Consol lovegrass (Table 4.2.2). Lines which performed well in winter/spring were the native species *Austrodanthonia pilosa* (Dp1) the cocksfoots cv. Currie, F066 and F083, and an acid-tolerant phalaris from CSIRO (Figure 4.2.2). Lines which performed well in spring/summer were Consol lovegrass, the native species *Themeda australis* (Lig165) and several cocksfoots. Consistent producers in summer only were the C_4 species *Bothriochloa macra* and *Chloris truncata* (Table 4.2.2). Some C_4 species (e.g. *Dichanthium sericeum*, *B. macra*) were severely affected by frost in winter and, thus, had nil or very little production in winter and spring.

Superior lines at individual samplings (i.e. significantly greater yield than others) were:

Winter 1999:	Cocksfoots 1784, Currie, 1795, *A. pilosa* (Dp1*)*
Spring 1999:	Cocksfoots Currie, F083, F066, *A. pilosa* (Dp1*)*, Taranna wallaby grass, phalaris (AT96)
Summer 99/00:	Consol lovegrass, *T. australis* (Lig165)

Winter 2000: Top 11 equal

Spring 2000: *T. australis* (Lig165), Consol lovegrass, Cocksfoots F066, F083, *A. pilosa* (Dp1*)*

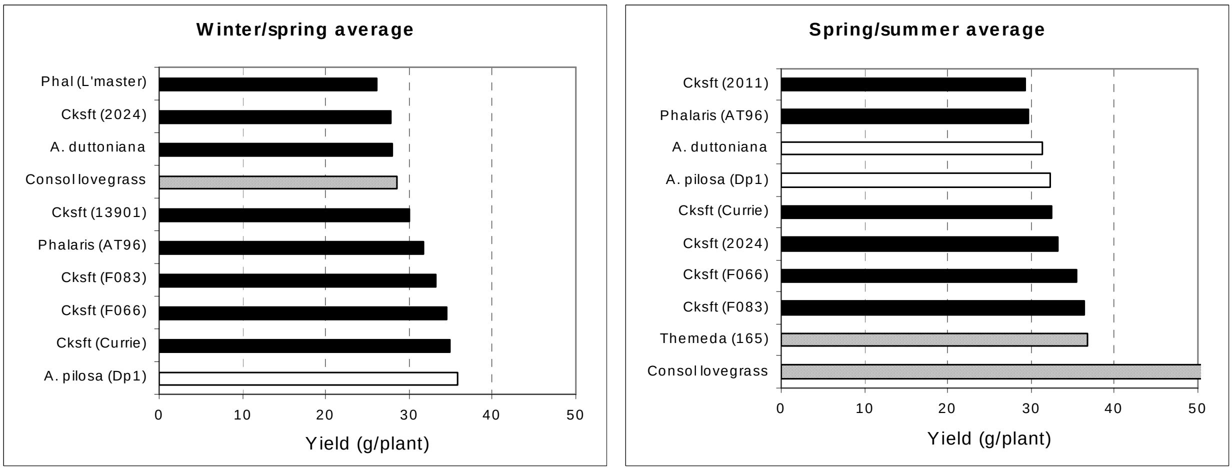
Summer 00/01: Consol lovegrass, *B. macra*

Table 4.2.2: Yield and survival of lines which were ranked in the top 10 more than twice at 6 samplings at Sutton, NSW (Lines with shaded cells were ranked in the top 10 at that sampling).

	RANK TOTAL[A]	**Winter 1999**	**Spring 1999**	**Sum 1999/00**	**Win 2000**	**Spring 2000**	**Sum 2000/01**	**Survival**
		(g/plant)						(%)
Currie Cocksfoot	5	12.2	28.4	11.5	6.9	22.5	3.6	37.2
Cocksfoot (2024)	5	8.8	15.5	22.5	7.3	23.8	4.4	62.7
Consol lovegrass	4	2.4	13.8	52.4	9.2	31.9	17.0	100
A. pilosa (Dp1)	4	11.9	25.9	9.5	7.1	27.0	1.8	94.8
T. australis *(Lig165*)	4	3.4	6.9	28.1	6.8	32.0	6.9	100
Taranna wallaby grass	3	7.5	23.0	21.7	4.2	11.2	2.4	90.5
Cocksfoot (13901)	3	8.4	17.6	6.8	9.7	24.2	0.0	11.5
Cocksfoot (F066)	3	10.4	23.5	16.5	5.1	30.2	0.5	76.3
Cocksfoot (F083)	3	9.1	25.0	20.5	6.3	26.1	1.1	46.7
M. stipoides (Ms2)	3	4.0	16.2	18.7	7.3	11.2	2.4	100
Phalaris (AT96)	3	8.7	22.9	13.9	9.5	22.1	0.3	81.1
Cocksfoot (1795)	2	10.8	10.4	18.8	5.0	13.0	5.5	40.5
A. duttoniana	2	5.4	21.8	14.3	4.7	24.1	1.4	100
A. caespitosa (Dc1)	2	8.9	18.8	17.2	3.7	8.1	1.0	88.5
A. caespitosa (2407)	2	6.0	18.1	15.2	6.7	12.4	0.6	50
B. macra	2	0.0	1.3	32.7	0.0	0.0	10.0	94.8
C. truncata	2	0.0	7.5	21.93	0.7	6.3	5.6	100

[A] Number of samplings ranked in the top 10 on yield

Figure 4.2.2: Top 10 yielding lines in winter/spring and spring/summer (solid bars: C3 introduced species; open bars: C3 native species; hatched bars: C4 species).



(b) **Survival**

Each time plots were sampled for yield, surviving original plants were counted. However, only the data recorded in February 2001 are presented, as these record survival of plants over the whole experimental period. The survival of highly ranked lines is shown in Table 4.2.2. Statistically, species fell into two distinct groups at the level of 60% survival (i.e there was no statistical difference between lines with survival above 60%, but these were different from those with survival below 60%). Apart from *E. curvula*, the only lines with survival above 90% were native species. On the other hand there were some native species with poor survival, notably Bunderra wallaby grass and *Dichanthium sericeum* (less than 30%).

(c) **Recruitment**

Recruitment of seedlings was recorded within bare areas between the original spaced plants. A grid with 81 (10 cm x 10 cm) squares was used and the number of squares with seedlings in them recorded as frequency. Results for the top 12 ranked surviving lines in December 2000 (those with frequency >80%) are shown in Table 4.2.3. At this sampling, the frequency of seedlings for all lines ranged from 1.2 to 100%, with only 2 exotic species (phalaris AT96 and cocksfoot F066) occurring in the top 16. The lowest amount of recruitment was recorded for 2 cocksfoots (1703 and F083 - both 1.2% seedling frequency). There were some surprises in the results, with AT96 phalaris (normally regarded as a poor recruiting species) having a seedling frequency of 98.1% and Shannon microlaena (expected to be a reliable recruiter) having a frequency of 4.3%. Results for other lines of the same species were:

Phalaris (Landmaster)	47.5%	*M. stipoides*	2402	96.9%
			Ms1	80.9%
			cv. Wakefield	72.8%
			Lig183	56.2%
			Ms2	46.9%

Table 4.2.3: Recruitment of seedlings of lines with seedling frequency >80% at the December 2000 sampling (% of squares in a 90 cm x 90 cm grid with seedlings present).

	Sampling date			
	9 June 1999	**13 Sept 1999**	**18 July 2000**	**9 Dec 2000**
A. fulva (Dlf1)	61.1	67.3	100	100
Phalaris (AT96)	96.9	41.4	46.9	98.1
M. stipoides (2402)	75.9	79.6	95.7	96.9
A. racemosa	63.6	66.0	97.5	95.7
Cocksfoot (F066)	35.8	34.0	91.4	93.8
B. macra	21.0	43.8	91.4	92.6
A. caespitosa (Dc1)	6.2	21.6	94.4	92.0
A. pilosa (2402)	71.6	74.7	90.1	92.0
A. duttoniana	37.7	22.8	88.9	88.9
A. pilosa (Dp1)	50.0	0.0	37.0	88.3
D. sericeum	60.5	59.9	81.5	81.5
M. stipoides (Ms1)	3.1	17.9	74.7	80.9

4.2.3 Discussion

On the basis of yield, several native and introduced lines have shown some promise in this experiment. However, attention also needs to be paid to survival of sown plants and establishment of new plants through recruitment before making recommendations. In a difficult environment, there is little point in sowing a plant which may have high yield, but which does not persist. Table 4.2.4 summarises data on yield, survival and recruitment for the range of lines listed in Table 4.2.2. It should be borne in mind that different plants have different survival strategies. Some may have high population turnover, with greater dependence on recruitment, whereas others are highly persistent, relying less on recruitment of new plants. Both these strategies are valid, as long as the population persists.

On the basis of total yield, Consol lovegrass was the most productive line, and also had very high survival. This species, and *T. australis* (Lig165), *C. truncata*, *M. stipoides* (Ms2) and Taranna wallaby grass, clearly rely on persistence of mature plants rather than rapid population turnover, since their levels of recruitment were only low to moderate, but they had high survival. Other lines, such as *A. duttoniana*, *B. macra*, *A. pilosa* (Dp1), *A. caespitosa* (Dc1), phalaris (AT96) and cocksfoot (F066) had both high survival and high recruitment. However, they were not all highly productive. Lines with high yield and either good survival or good recruitment (or both) included Consol lovegrass, cocksfoots F066 and 2024, *T. australis* (Lig165*)*, *A. pilosa* (Dp1), phalaris AT96, *A. duttoniana* and Taranna wallaby grass.

Table 4.2.4: Total yield, percent survival and percent seedling frequency of the most productive lines listed in Table 4.2.2 (ranked according to total yield).

	Total yield[A] (g/plant)	**Survival (%)**	**Seedling frequency (%)**
Consol lovegrass	126.7	100	48.1
Cocksfoot (F083)	88.1	46.7	1.2
Cocksfoot (F066)	86.2	76.3	93.8
Currie cocksfoot	85.1	37.2	11.7
T. australis *(Lig165)*	84.1	100	25.3
A. pilosa (Dp1)	83.2	94.8	88.3
Cocksfoot (2024)	82.3	62.7	49.4
Phalaris (AT96)	77.4	81.1	98.1
A. duttoniana	71.7	100	88.9
Taranna wallaby grass	70.0	90.5	51.9
Cocksfoot (13901)	66.7	11.5	50.6
Cocksfoot (1795)	63.5	40.5	50.0
M. stipoides (Ms2)	59.8	100	46.9
A. caespitosa (2407)	59.0	50	64.2
A. caespitosa (Dc1)	57.7	88.5	92.0
B. macra	44.0	94.8	92.6
C. truncata	42.0	100	13.0

[A] Total of 6 samplings from winter 1999 to summer 2000/2001

4.2.4 Recommendations

Recommendations need to be considered in light of the purpose for which a new species is sought. If the intention is to obtain a new introduced C_3 species for sowing in difficult environments, then cocksfoot F066 is clearly worthy of further evaluation. It is similar in productivity to the commercial cultivar Currie, but with markedly better survival and recruitment. Cocksfoot 2024 might also be considered, as it also has higher survival and recruitment than cv. Currie, and similar production. Cocksfoot F083, while promising in terms of yield, had poor survival and even poorer recruitment. Phalaris AT96 is also worthy of attention, as it had superior yield, survival and recruitment to the commercial cultivar Landmaster at this site. The introduced Consol lovegrass was clearly superior to any other C_4 lines in this experiment and, indeed, to all other lines.

Among the native species, *Austrodanthonia pilosa* (Dp1) and *A. duttoniana*, selections from the environment in which this experiment was conducted, showed considerable promise. These were the only native species to be ranked in the top 10 in terms of overall winter/spring growth, and the only C_3 native species to be ranked in the top 10 in terms of overall spring/summer growth. (Figure 4.2.2). They also had high survival and recruitment. These species should be investigated further. For summer growth, the C_4 *Themeda australis* (Lig165) was the best of the native species, with improving production as the experiment progressed, and very high survival. *Bothriochloa macra*, while producing well in summer, and having very good survival and recruitment, was severely affected by frost in winter, and was slow to recover from this in spring. This line may be more suited to warmer environments.

4.3 Rutherglen, Vic

(M Mitchell, Department of Natural Resources and Environment, Vic)

4.3.1 Site description

The site is located at Springhurst, approximately 30km south of Rutherglen in northeast Victoria. Altitude at the site is 300m , and it has a winter dominant rainfall pattern, with hot dry summers. The average rainfall is 680 mm. Soil characteristics of the site are shown in Table 4.3.1. and rainfall received at the site in Table 4.3.2.

The pasture was an annual pasture at the time of grass establishment, the major species being capeweed (*Arctotheca calendula*), annual ryegrass (*Lolium rigidum*), sorrel (*Rumex acetosella*), erodium (*Erodium cicutarium*) and subterranean clover (*Trifolium subterraneum*).

No fertiliser had ever been applied to the experimental site, and it had been used for grazing since it was cleared in the 1950's. Prior to grass establishment it was being grazed by sheep at 5 DSE/ha. This type of landuse and fertiliser history is common for this landscape class.

Table 4.3.1: Characteristics of soil at the experimental site at Rutherglen.

Soil pH ($CaCl_2$)	4.49	Exchangeable Al (cmol/kg)	0.00
Available P (Olsen, mg/kg)	4.20	Exchangeable Mn (cmol/kg)	0.10
Exchangeable Mg (cmol/kg)	0.96	Cation exchange capacity (cmol/kg)	7.08
Exchangeable K (cmol/kg)	1.02	Soil Organic Carbon (%)	2.18
Exchangeable Na (cmol/kg)	0.03	Total N. (%)	0.16
Exchangeable Ca (cmol/kg)	4.97	Electrical conductivity (dS/m)	0.08

Table 4.3.2: Monthly rainfall at the Rutherglen site from January 1998 until May 2001.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998	11	31	2	102	5	67	79	60	100	52	104	33	646
1999	43	8	84	21	102	68	47	88	55	49	54	102	721
2000	11	37	82	44	100	52	31	70	101	112	66	5	711
2001	55	84	42	19	25								

4.3.2 Site preparation and seedling production

The fence was erected in June 1998 and weed matting laid in July 1998. Prior to this the site was sprayed with Roundup to control existing grass cover. The native grass seeds were germinated on heated beds and then pricked out into seedling trays containing a potting mixture of 33% sand, 33% peat and 33% vermiculite. The introduced species were sown directly into the seedling trays, with one seed per cell. Soluble fertiliser was applied. The plant material was raised in a polyhouse and then hardened off under shade cloth before being planted out.

4.3.3 Field planting

The seedlings were transplanted at the end of March 1999. Both C_3 and C_4 species were planted out together. The site was watered for six weeks to aid establishment. The weed matting was removed in March 2000. On 13 March 2001, 125 kg/ha single superphosphate were applied to the experimental site.

4.3.4 Grass performance

Thirty-two different species and accessions were evaluated in the experiment. Eleven were chosen as having the best potential for further development. All eleven accessions chosen are C_3 (two species of *Austrodanthonia*, one accession of *Elymus scaber*, four accessions of cocksfoot, and four accessions of *Microlaena stipoides*). Data will be presented only for these species and accessions in the remainder of this report.

(a) Herbage production

Dry matter harvests were conducted on 3 November 1999, 6 March 2000, 7 June 2000, 29 October 2000, 20 February 2001 and 22 May 2001. At the June 2000 harvest, yield of all accessions was low, and there were no significant differences in dry matter production (Table 4.3.3). All the selected accessions yielded well in October 2000 (Table 4.3.4) following the favourable seasonal conditions. There was no significant difference in the dry matter production of the *M. stipoides* accessions for the October 1999, June 2000 and May 2001 harvests (Table 4.3.3). Overall, there was a general decrease in dry matter production throughout the experiment. This was most likely due to the method of harvesting the plots and declining soil fertility status of the site.

Table 4.3.3: Herbage mass (g/plant) of selected species and accessions at five harvests at Rutherglen together with the total herbage mass summed over all harvests. Values within a column with different superscripts are significantly different ($P<0.05$).

Species and accession	**Oct-99**	**May-00**	**Jun-00**	**Oct-00**	**Feb-01**	**May-01**	**Total**
	g/plant						
A. fulva (Dlf1)	3.5c	2.2f	NA	48.1abc	11.2c	1.9b	92.0
A. fulva (Lig179)	1.7c	NA	NA	37.7cd	10.0d	4.3a	114.6
Cocksfoot (F066)	10.9bc	3.1e	5.6	51.2ab	4.0g	1.3b	114.1
Currie cocksfoot	41.0a	12.9c	1.8	42.6bcd	3.5gh	0.5b	152.3
Cocksfoot (F083)	20.0b	15.5b	3.5	42.6bcd	2.8h	1.1b	133.4
Cocksfoot (2024)	34.7a	18.3a	0.1	46.3abc	10.5cd	2.1b	156.9
E. scaber (Lig473)	11.0bc	4.7d	2.5	34.6d	8.4e	1.7b	105.9
M. stipoides (Lig183)	3.4c	NA	4.1	54.9a	13.5b	2.0b	131.9
Shannon microlaena	1.4c	NA	3.6	54.9a	16.8a	1.0b	106.7
Wakefield microlaena	0.8c	NA	1.8	51.9ab	11.3c	1.7b	101.5
M. stipoides (2402)	6.6bc	12.1c	2.3	51.2ab	6.8f	1.3b	80.4
LSD (P=0.05)	14.6	0.8	NS	11.2	0.8	1.9	

(b) **Persistence**

Persistence counts were conducted on 31 May 1999 and 31 August 1999 prior to the removal of the weed matting, and final plant persistence counts on 22 May 2001. Seedling recruitment was recorded on 25 October 2000 and 22 May 2001. The accessions included in this report were chosen based on a combination of persistence of the original plants and recruitment of seedlings. Although survival of original plants of the selected accessions is high (Table 4.3.4), plant numbers have declined with time. Again, this can probably be attributed to the declining fertility status of the soils. For some of the selected accessions a high seedling frequency was also recorded (Table 4.3.4), indicating that some accessions have the ability to reproduce under the experimental conditions, as well as the original plants surviving. An example of this is *M. stipoides* (Lig183). A second strategy, with high survival of original plants and few seedling recruits within the plots, was shown by *E. scaber* (Lig473).

(c) **Palatability**

The relative palatability of the entries was evaluated in May 2001. Thirty merino wethers grazed the plots, and the amount of each accession that was eaten was scored (0-9). Of the accessions included in this report a marked difference can be seen in the palatability of the *M. stipoides* accessions (Table 4.3.4), with accession Lig183 having a markedly lower palatability score.

4.3.5 Discussion

The results from the Rutherglen site indicate that 11 accessions have the potential for commercialisation. Of the accessions selected as the best performers at the Rutherglen site one is commercially available (Currie cocksfoot) and two have been registered under Plant Breeders Rights (Shannon and Wakefield microlaena). The eight remaining entries had performance that was comparable to these commercially available accessions. For any of the lines from this experiment to be commercially available, more research is required on seed production, sowing methods and animal production.

Several of the accessions of cocksfoot evaluated in this experiment had problems with rust. The accessions selected did not have this problems, but future cocksfoot evaluation programs need to keep this in mind.

Table 4.3.4: Plant survival, seedling frequency and palatability scores of selected accessions at Rutherglen.

Species and accessions	**Entry No.**	**Surviving plants**[A]		**Seedling frequency (%)**	**Palatability score (0-9)**
		Oct-99	**Apr-01**	**Oct-01**	**30/5/01**
A. fulva (Dlf 1)	34	15.8	15.0	48.8	6.5
A. fulva (Lig179)	38	15.5	15.5	38.1	6.5
Cocksfoot (F066)	22	16.0	15.0	51.9	8
Currie cocksfoot	1	16.0	15.5	46.3	9
Cocksfoot (F083)	23	16.0	16.0	46.3	9
Cocksfoot (2024)	8	16.0	12.0	46.3	8.5
E. scaber (Lig473)	43	15.5	15.5	35.0	8.5
M. stipoides (Lig183)	40	16.0	16.0	60.0	4.5
Shannon microlaena	7	15.8	14.5	55.6	6
Wakefield microlaena	6	16.0	16.0	52.5	7.5
M. stipoides (2402)	39	15.8	12.5	50.0	9

[A] Original total 16

4.4 Jericho, Tas

(DA Friend, EJ Hall, AM Hurst, Tasmanian Institute of Agricultural Research)

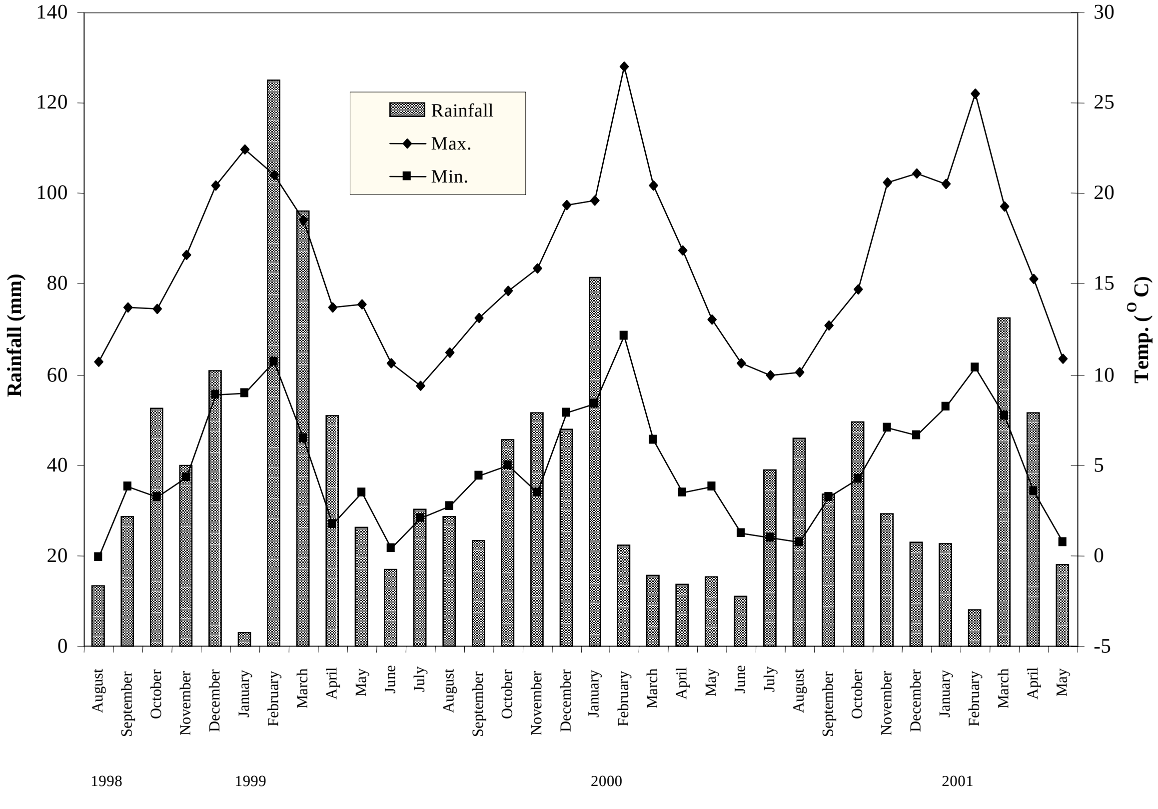
4.4.1 Site description

The site at Jericho is located in the southern Midlands of Tasmania (147º19´E, 42º 22´S), at an altitude of 420 m. The climate is cool-temperate, with mean June max/min temperatures of ca. 9.4/1.1ºC and mean January max/min temperatures of ca. 21.9/8.8ºC; mean annual rainfall is ca. 550 mm. The site is situated in a valley flat on alluvial soil consisting of a sandy clay loam (pH [CaCl2] 4.8; P (Olsen) 7 mg/kg) over a medium-heavy clay at ca. 40 cm.

The main feature of the weather over the period of the experiment was the very dry winters (Figure 4.4.1). The normal rainfall pattern is average falls of 40-50 mm each month. There were good rainfalls in summer and early autumn 1999, in January 2000 and in early autumn 2001, but otherwise, conditions have been very dry. Rainfall in the first half of 2000 was about the lowest on record.

August 1998 was particularly cold, with severe frosts, making establishment difficult. There were further severe frosts in April 1999 which killed or damaged many plants. On the other hand, unusually high temperatures in February 2000 and 2001 further exacerbated the dry conditions.

Figure 4.4.1: Monthly rainfall and mean monthly maximum and minimum temperatures at Jericho from August 1998 to May 2001.



4.4.2 Accessions evaluated

In addition to a range of cocksfoot and native grass accessions, four other introduced species were evaluated at Jericho (Table 3.2.1): two species of *Festuca* (*F. ovina* and *F. idahoensis*), together with *Bromus biebersteinii* and *Elymus trachycaulis*. These accessions had shown promise in earlier evaluation work in Tasmania. Several C_4 species tested at other sites were not included at Jericho (e.g. accessions of *Enteropogon*, *Dichanthium* and *Paspalidium*). However, C_4 accessions of *Themeda*, *Bothriochloa* and *Chloris* were included. Porto cocksfoot was included in the experiment because it is the main cocksfoot sown in the region.

4.4.3 Planting, establishment and management

Plant establishment, site management and measurements generally followed the protocols outlined in Section 3. The C_3 species were transplanted on 13 August 1998, and the C_4 species on 16 October 1998. Some irrigation was necessary in the first spring to ensure establishment. Plants that failed to establish were replaced in the first spring, C_3 species on 16 October and C_4 species on 9 November 1998. Grazing by sheep (*c*. 100 DSE/ha for 1 day) was used to control annual grass weeds after harvests were taken on several occasions. No observations were made on palatability because poor growth following the last harvest in March 2001 meant that there was little plant material to graze.

4.4.4 Grass performance

(a) **Herbage production**

Dry matter harvests were taken in summer (March) 1999, 2000 and 2001, winter (June) 1999 and 2000, and spring (October/November) 1999 and 2000. There were highly significant differences ($P<0.001$) in yield between the test accessions at each harvest. The highest yielding accessions were the summer active cocksfoots, 1795, 2011, F146, F066, and Porto (Figure 4.4.2). The yields of cocksfoots 1784 and Currie, which have some summer dormancy, were significantly lower ($P<0.05$) in summer 1999 and 2000 than the two top yielding summer active accessions (1795 and 2011). The accessions 1703, 1715 and 13939, are highly summer dormant, and their yields in summer were significantly lower ($P<0.05$) than all the summer active species. However, these latter three accessions have made good autumn and winter growth. There were no significant differences in spring yield, and few significant differences in winter yield between the cocksfoots.

Landmaster phalaris, which has some summer dormancy, showed good autumn regrowth and yields not significantly different to that of the cocksfoots in winter and spring (Figure 4.4.2). *Festuca idahoensis*, which is highly summer dormant, also had good winter and spring production that was not significantly different from that of the cocksfoots. *Bromus biebersteinii*, a summer active species, was slow to establish, but was the fourth highest yielding accession in summer 2001.

Elymus scaber was the best of the native grasses, with good winter growth (Figure 4.4.2). *Austrodanthonia fulva* (Dlf1) exhibited good year-round growth. This accession established well and out-yielded the other *Austrodanthonia* accessions at most harvests. However, differences in production between the top five yielding *Austrodanthonia* accessions shown in Figure 4.4.2 were significant ($P<0.05$) only at the first harvest. The other *Austrodanthonia* accessions, all the *Microlaena* accessions and the C_4 species had very low production (mean annual yield <11.3 g/plant).

(b) Survival

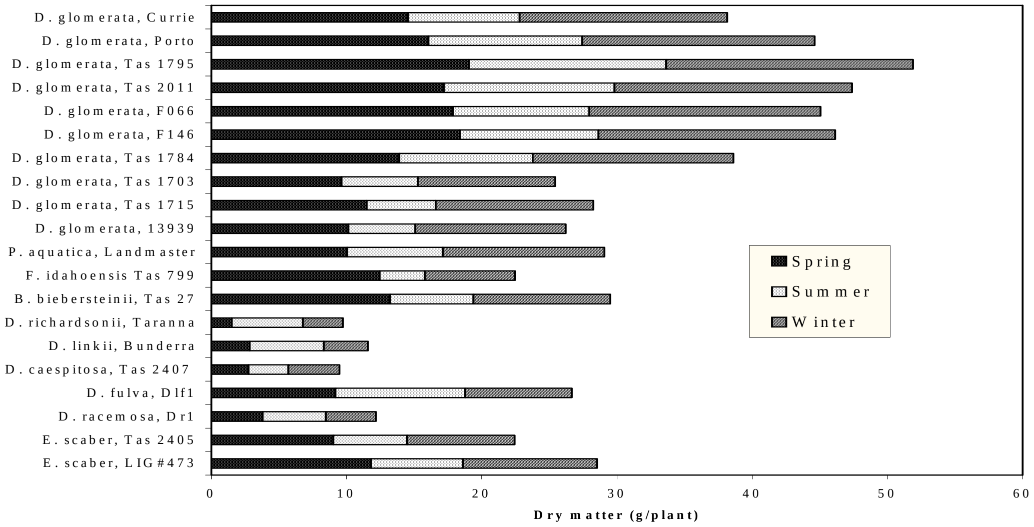
Plants were rated for frost damage in May 1999 after severe autumn frosts (three consecutive days in April with -7.7º, -7.2º and -5.9ºC). A further rating for frost damage was made in October 1999 after another series of heavy frosts. The low persistence of C_4 species (Table 4.4.1) was associated with frost damage. Accessions of *Microlaena* were also badly affected by frost in the first year. In some *Microlaena* accessions most plants subsequently recovered, but in others, mortalities were high. Some accessions of *Austrodanthonia* were also affected by frost and some plants were lost. Amongst the cocksfoots and other introduced plant accessions, with the exception of *Festuca ovina*, there were few losses.

(c) Seedling recruitment

Frequency counts to record recruitment were made in May and August 2000, but a frequency count scheduled for May 2001 was not made because a dense stand of annual grass weeds made identifying seedlings and small plants of the test lines too difficult. Seedling recruitment in August 2000 (Table 4.4.1) was the result of germination in winter and spring the previous year. Differences between species in recruitment were highly significant ($P<0.001$). The summer active cocksfoots all had relatively low recruitment in the plots, but seedlings were more prominent in the pathways between plots. This was presumably the result of competition from the established plants on the plots. The highest recruiting cocksfoots were the summer dormant accessions 1715 and 1703 (Table 4.4.1). The other introduced accessions had low to moderate recruitment rates.

A. fulva (Dfl1) and *A. racemosa* were the highest recruiting *Austrodanthonia* accessions (Table 4.4.1). *A. caespitosa* (2407) had reasonable recruitment rates, which may offset to some extent its poor persistence. Other *Austrodanthonia* accessions, and all *Microlaena* accessions had very low recruitment rates.

Figure 4.4.2: Mean dry matter yields of selected test accessions at Jericho based on harvests in spring (two harvests), summer (three harvests) and winter (two harvests).



4.4.5 Discussion

The summer active cocksfoots have been the most productive accessions tested in this experiment. However, none of the new accessions consistently yielded higher than Porto, the cultivar currently sown in the region. The highest yielding cocksfoot (1795), has been evaluated in other trials in Tasmania, and also has not performed significantly better than Porto. Although high yielding in this experiment, these summer active cocksfoots are not suitable for use where summer drought is severe. On the other hand, the summer dormant cocksfoots have demonstrated their value on dry north-facing slopes in the southern Midlands in other experiments (Hall 2001). A selection from the fine-leaf, summer dormant 1703 is currently at an advanced stage towards release under PBR. We are not considering any further evaluation work on the other Tasmanian cocksfoot accessions.

Of the other introduced accessions, *Bromus biebersteinii* warrants more evaluation work. Although slow to establish, it gave good winter and early spring production (spring harvest). The species has a high palatability (E. Hall, personal observations), high survival rate and a rhizomatous habit, which make it a desirable pasture type. Although *Festuca idahoensis* also performed well in this experiment, it has failed to persist in dry years in other experiments in Tasmania.

Some of the native grass accessions persisted well in this experiment and have proved to be quite productive, in particular, two accessions of *E. scaber* (2405 and Lig473) and *Austrodanthonia fulva* (Dlf1). The C_4 grasses all performed poorly, and are obviously not adapted to the cold conditions at Jericho, although *Themeda australis* occurs throughout the Midlands and at higher altitudes than Jericho. The *Microlaena stipoides* accessions also appeared to not be well adapted, again despite this species occurring in the region. We were also surprised at the way many *Austrodanthonia* spp. evaluated in this experiment were damaged by frost.

A. fulva (Dlf1) warrants more evaluation work. In particular, information is needed on its palatability and forage quality as plants of this accession were quite long in the stem. Unfortunately, no information on palatability was obtained from this experiment. *A. caespitosa* (2407) is currently being evaluated in other trials in Tasmania and has performed well in swards. *E. scaber* (2405), on the other hand, has performed poorly in swards. Although native grass accessions from outside Tasmania would be suitable for use in re-establishing run-out improved pastures, they would not be suitable for re-establishing native pastures. One hundred and twenty eight different native grass accessions, including *Austrodanthonia* spp., *Microlaena stipoides*, *Elymus scaber*, *Poa* spp. and *Austrostipa* spp. are currently being evaluated in a spaced plant nursery in Tasmania.

Table 4.4.1: Survival and recruitment of test accessions at Jericho, Tasmania.

Species	**Accession**	**Survival**[a]	**Recruitment**[B]
Dactylis glomerata	Currie	16.0	35.0
D. glomerata	Porto	16.0	15.0
D. glomerata	Tas 1795	16.0	25.0
D. glomerata	Tas 2011	15.5	3.5
D. glomerata	Tas 2024	14.5	12.5
D. glomerata	F066	16.0	16.0
D. glomerata	F146	15.5	22.0

Species	Accession	Survival[a]	Recruitment[B]
D. glomerata	Tas 1784	15.0	40.0
D. glomerata	Tas 1703	12.5	53.5
D. glomerata	Tas 1715	15.5	62.5
D. glomerata	13939	13.5	20.5
Phalaris aquatica	Landmaster	14.5	7.5
Festuca ovina	Tas 829	8.5	37.0
F. idahoensis	Tas 799	12.0	44.0
Elymus trachycaulus	Tas 1143	14.5	11.5
Bromus biebersteinii	Tas 27	15.5	18.5
Austrodanthonia richardsonii	Taranna	10.0	18.5
A. bipartita	Bunderra	16.0	5.5
A. caespitosa	Tas 2407	9.5	42.0
A. caespitosa	Dc1	3.5	3.0
A. fulva	Lig179	9.0	13.0
A. fulva	Dlf1	16.0	65.5
A. racemosa	Dr1	15.5	68.0
A. pilosa	Tas 2404	3.5	24.5
Microlaena stipoides	Wakefield	7.0	1.5
M. stipoides	Shannon	9.5	5.5
M. stipoides	Tas 2402	0.0	2.5
M. stipoides	Ms1	11.5	11.5
M. stipoides	Lig183	12.5	5.0
Elymus scaber	Tas 2405	11.0	9.0
E. scaber	Lig473	12.5	28.5
E. scaber	Es1	12.5	44.5
Themeda australis	Tas 2406	1.0	0.0
T. australis	Lig165	0.0	0.0
Bothriochloa macra	Lig002	0.0	0.0
Chloris truncata	Lig547	0.0	0.0
LSD (P=0.05)			22.0

[A] Plants surviving to 28 March 2001 from original 16 plants

[B] Percentage frequency of seedlings in a 9 x 9 grid of 10 x 10 cm quadrats

4.5 Trangie, NSW

(C Waters, I Toole, NSW Agriculture)

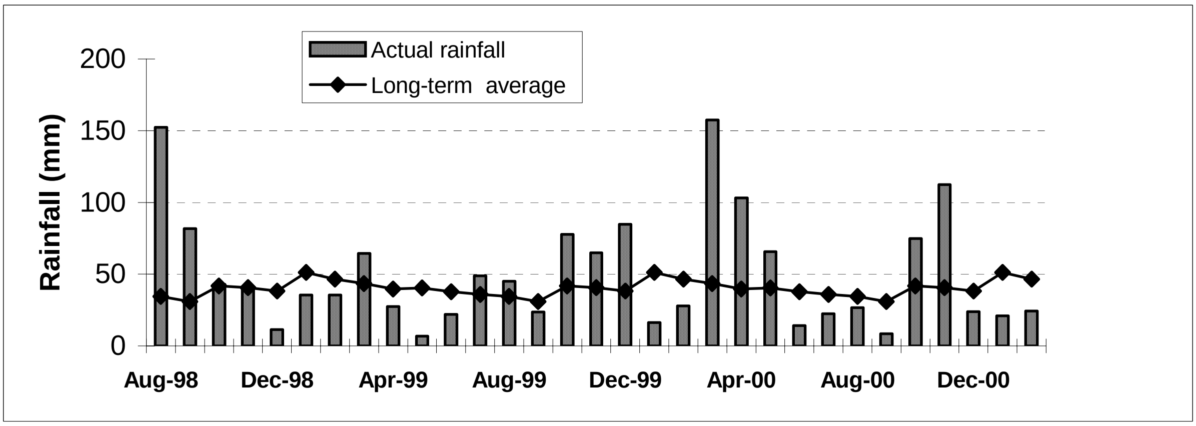
4.5.1 Site description

This site is at Trangie Agricultural Research Centre (31^0 50'S, 147^0 57'E), located on the central western plains of New South Wales. The soil is a hard setting red earth that has a low pH and available P (Table 4.5.1). The average long-term annual rainfall is 480 mm, typically non-seasonal and highly variable. Since the commencement of this project in August 1998 and for each successive year this site has received well above average seasonal rainfall, almost twice the annual long-term average each year (Figure 4.5.1). Temperatures were also milder than expected over spring 1999 and autumn 2000. These ideal growth conditions resulted in unusually high survival rates and biomass production for many species, in particular cocksfoot, which does not normally produce well in these marginal cropping areas.

Table 4.5.1: Soil chemical analysis (0-10 cm) at Trangie site prior to the establishment of the experiment.

pH ($CaCl_2$)	Olsen P (mg/kg)	S (%)	N (%)	C (%)	EC (dS/cm)
5.9	7.0	0.01	1.7	1.7	0.20
K	**Ca**	**Mg**	**Al**	**Na**	**CEC (cmol/kg)**
1.17	9.14	3.68	0	0.19	14.24

Figure 4.5.1: Monthly rainfall and average long-term rainfall at the experimental site at Trangie, NSW.



4.5.2 Field planting

All C_3 grasses were sown in October 1998 and C_4 grasses 5-6 weeks later in November 1998. Replacement C_4 grasses were transplanted over a three-month period from December 1998. Weed matting was removed in October 1999.

4.5.3 Grass performance

(a) Herbage production

Data reported here are for dry matter cuts taken on six occasions 9/07/99 (winter 99), 22/09/99 (Spring 99), 27/04/00 (summer 99/00), 7/08/00 (winter 00), 26/09/00 (spring 00) and 12/02/2001 (summer 00/01). Production values of each accession were ranked from the highest to the lowest for each sampling date. Those accessions that ranked consistently in the top 10 at each sampling are presented in Table 4.5.2. Comparisons between these top 10 performing accessions for winter/spring and spring/summer periods are given in Figure 4.5.2.

Uncharacteristic seasonal conditions, in particular for the autumn and spring observations, resulted in both ‘out of season’ biomass production and flowering events over 1999 and 2000. For example, mild autumn temperatures and high rainfall resulted in many C_4 grasses extending their growing season and having the highest dry weights in winter 1999. The spring and summer months in 1999 received almost twice their expected monthly rainfall in three consecutive months resulting in the highest absolute dry weights for both C_3 and C_4 grasses in the summer 1999/2000 period. This compares with spring 2000, (a period preceded by a very dry winter), where the lowest dry weights were recorded.

Table 4.5.2: Yield and survival of lines which were ranked in the top 10 more than twice at 6 samplings at Trangie, NSW (accessions with shaded cells were ranked in the top 10 at that sampling)

	Rank Total[A]	**Winter 1999**	**Spring 1999**	**Summer 1999/00**	**Winter 2000**	**Spring 2000**	**Summer 2000/01**	**Survival**
		(g/plant)						(%)
Consol lovegrass	6	41.5	44.8	77.7	4.6	3.7	20.1	97.2
Bunderra wallaby grass	5	47.5	18.3	55.8	4.0	4.6	16.1	100
E. scaber (Lig473)	4	30.1	19.2	53.8	12.1	5.3	16.1	92.6
T. australis (Lig165)	3	19.9	29.1	161.1	1.3	1.6	28.9	68.9
D. SERICEUM	3	54.0	11.2	140.6	0.5	0.2	13.6	18.2
P. constrictum	3	48.9	16.3	84.9	0.2	0.8	17.5	43.4
P. jubiflorum	3	42.6	10.3	82.0	0.2	1.5	25.2	81.7
Cocksfoot (1784)	3	39.3	14.8	75.3	5.3	1.6	11.5	97.2
Cocksfoot (1795)	3	46.7	16.8	61.6	4.8	1.3	10.6	97.2
B. MACRA	3	49.7	2.7	68.7	0.1	0.1	16.1	94.8
Currie cocksfoot	3	20.9	25.0	59.8	7.2	3.0	7.8	97.2
Taranna wallaby grass	3	37.3	19.1	38.8	1.9	2.7	13.0	90.8
Cocksfoot (13915)	3	29.5	23.8	26.6	4.0	1.9	3.8	90.8
Kasbah cocksfoot	3	6.9	24.7	10.1	4.6	2.3	12.0	7.3
A. LAPPACEA	2	38.8	5.1	59.7	0.1	0.1	14.6	97.2
Cocksfoot (13932)	2	43.6	23.9	45.4	2.8	1.6	8.1	46.6
A. PECTINATA	2	44.6	2.4	59.5	0.6	0.0	5.4	21.7
Cocksfoot (F083)	2	36.8	16.5	35.0	5.5	1.9	9.5	97.2
E. scaber (Es1)	2	10.1	20.4	25.7	1.2	1.9	8.2	25.0

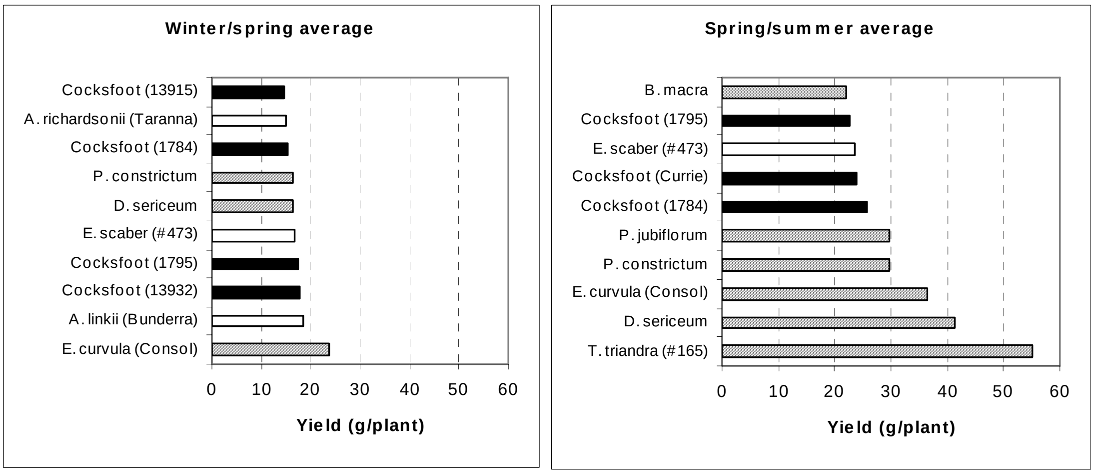
[A] Number of samples ranked in the top 10 on yield

Over each winter period various cocksfoot accessions and *Elymus scaber* (473) performed consistently better than other cool season species such as *Microlaena stipoides*. The cocksfoots with the highest dry weights were accessions 1795, 1784, 13915, and F083 and cv. Kasbah. Accession F083 also consistently produced more seed heads than other cocksfoot. *E. scaber* (473), a native cool season growing perennial, performed consistently well in all seasons.

Taranna and Bunderra wallaby grass each tended to have higher production levels, in spring and/or winter than *A. caespitosa* despite this latter species forming a major component of local native pastures and its success in an adjacent 1.6 ha seed production area at Trangie.

In summer the warm season C_4 grasses all tended to have higher production values than their C_3 counterparts. The only exception to this was the cocksfoot 1784 that seemed to exhibit some summer growth activity. Of the C_4 grasses, *Themeda australis* (Lig165), *Dichanthium sericeum* and *Paspalidium jubliflorum* each had the significantly highest production values. In each of the experimental years double or almost triple the amount of rainfall was experienced for this season. As each of these native grasses has a high requirement for water compared to other C_4 natives such as *Enteropogon acicularis,* this result is perhaps not surprising. The production of *Enteropogon acicularis*, another locally abundant native, was low, and this accession tended to exhibit poor seedling vigour, resulting in high mortality rates. Other C_4 natives (e.g. the two *Astrebla* spp.) also have a high summer water requirement but, in this case, their production levels were low. As these species are mainly found on self-mulching grey clays and are not well suited to the Trangie hard setting red soils this is perhaps not surprising. Consol lovegrass tended to perform above average in all seasons.

Figure 4.5.2: Top 10 yielding lines in winter/spring and spring/summer (solid bars: C_3 introduced species; open bars: C_3 native species; hatched bars: C_4 species).



As a group the cocksfoots tended to have higher production values than native species, especially in the cooler months. Over the summer months the differences between these two groups of plants becomes less obvious. Here, some natives such as *D. sericeum, T. australis* and *Paspalidium* spp. consistently achieved the highest production levels, whilst others such a *Chloris truncata* seemed to struggle from the beginning of the project. Given the ideal seasonal conditions and the weed control given by the weed matting, this suggests that these species (accessions) would not produce adequate levels of biomass in normal seasons in the Trangie area. The differences, in terms of production, between accessions or ecotypes within species suggest there is scope for selection between populations to develop useful cultivars. For example, of the two *E. scaber* accessions, Lig473 consistently had higher production than Es1.

(b) Persistence

Comparisons of plant survival rates are shown in Table 4.5.2. *M. stipoides* (2402) and *C. truncata* had the highest mortality rates (data not shown), with *Chloris* only persisting for the first year, a characteristic of this short lived perennial. Cocksfoots 13932 and cv. Kasbah and *D. sericeum* each had survival rates less then 50%, despite the latter accession producing large amounts of biomass per plant. Generally, the native grasses tended to have lower survival rates than exotic species under the conditions of this experiment.

4.5.4 Recommendations

For central western NSW, the lack of a dominant seasonal rainfall necessitates both cool and warm season species are sown as pastures mixes to provide year round fodder. Thus the importance of finding both C_3 and C_4 productive and persistent pasture species cannot be understated. In relation to our assessment criteria, Consol lovegrass*, E. scaber* (473) and *T. australis* (165) were the top three performers at the Trangie site. *E. scaber* is a cool season, C_3 grass that is rarely found in the Trangie area, which can be considered as its most western range. *T. australis,* a warm season perennial is widespread throughout this region.

The performance of both these lines warrants further evaluation. Consol lovegrass is a readily available exotic pasture species. However, despite its high performance in this and other local trials, it is not widely adopted for use by local graziers due to its perceived low palatability.

4.6 Binya, NSW

(MR Norton, E Koetz, NSW Agriculture)

4.6.1 Site Description

The Binya site (34° 08´S, 146° 17´E) is located approximately 40 km NE Griffith in the Riverina district of New South Wales. Binya is a mixed farming district in which joint cropping and livestock production enterprises are the most important activities. A site described by the farmer as a ‘barley’ paddock was selected. The paddock was considered only likely to be taken out of pasture and cultivated when barley prices were high. A typical pasture phase was considered likely to last 7-8 years on this soil type by the owner.

Average rainfall is ca. 420 mm, evenly distributed throughout the year (Table 4.6.1). However, the reliability of rainfall and the number of rain days are greater throughout the winter months than in summer. The low level of evapotranspiration over the cooler months, in contrast to summer, causes rainfall at that time to be highly effective. Nevertheless, substantial pasture growth can occur over summer, and one of the major species endemic to the site was the C_4 grass *Dichanthium sericeum,* a species which requires summer rainfall. Rainfall for 1998 was somewhat below the long-term average while a much higher level than the mean was received in 1999. The year 2000 saw higher rainfall than the average, while the first 6 months of 2001 were below average. Mean maximum temperature of the hottest month (February) is 31.5°C and the 86th percentile maximum temperature then is 36.6°C. The coldest month is July, during which the mean minimum temperature is 2.5°C and the 14th percentile is –1.4°C. Ground frost may occur between May and September.

Table 4.6.1: Monthly rainfall at the Binya NLIGN site over the duration of the experiment.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998	52	19	0	30	16	44	32	45	84	28	25	8	383
1999	74	23	122	29	39	27	44	40	62	102	29	93	684
2000	18	44	32	43	72	36	22	47	22	74	68	5	483
2001	26	58	27	30	10	29							

Soils at the site were sampled prior to the commencement of the experiment (Table 4.6.2). Available phosphorus was very low at 5.47ppm. The Mg/Ca ratio and the level of Na indicated that soil structural problems were possible and that gypsum application might be advisable. However, no soil ameliorant or fertiliser was applied as it was considered that this would be unlikely to occur at a “low input” site.

Table 4.6.2: Key soil descriptors (0-10cm) of the Binya NLIGN site in February 1998.

pH	EC	C%	S%	N%	P	ECEC
6.21	0.13	1.18	0.01	0.1	5.47	15.32
Al	**Mn**	**Na**	**Mg**	**Ca**	**K**	**Texture**
0.0	0.13	1.06	5.55	7.78	0.8	Medium clay

Legend and analytical methods

pH – 1:5 soil/0.01M CaCl2 extraction.
EC – Electrical conductivity (dS/m), 1:5 soil/water extraction.
ECEC – Exchangeable cations (cmol/kg), BaCl2 /NH4Cl extraction, Flame AAS.
Bray No. 1 Phosphorus – Extractable P (mg P/kg), spectrophotometer.
C, N, S – Total Carbon, Nitrogen & Sulphur, LECO CNS analyser.

4.6.2 Site Establishment

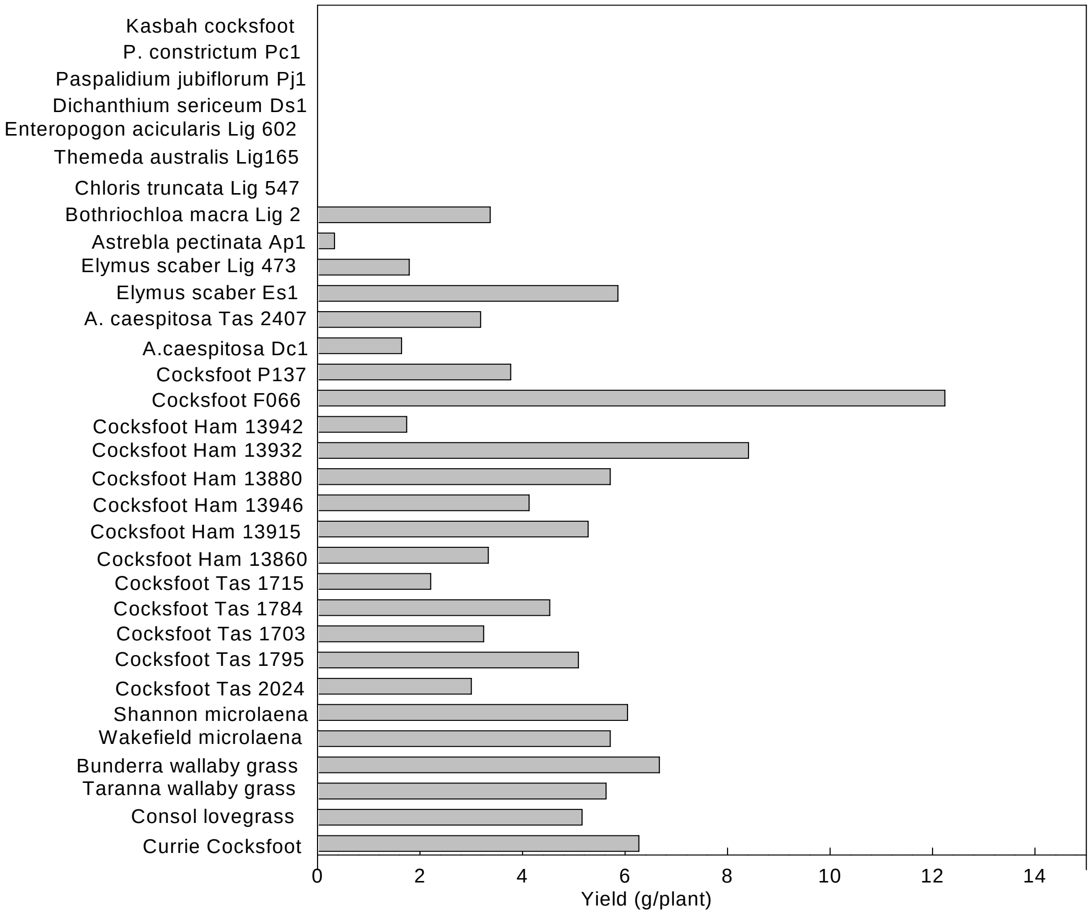
Establishment commenced in August 1998 with the C_3 grasses transplanted first, while the C_4 grasses were transplanted once the danger of frosts had past. Considerable numbers of C_3 accessions did not survive the summer of 1998/99 even though supplemental irrigation was applied to assist survival. These were resown in early 1999. All plots were established on weed matting and this was removed in October 1999.

4.6.3 Grass performance

(a) Herbage production

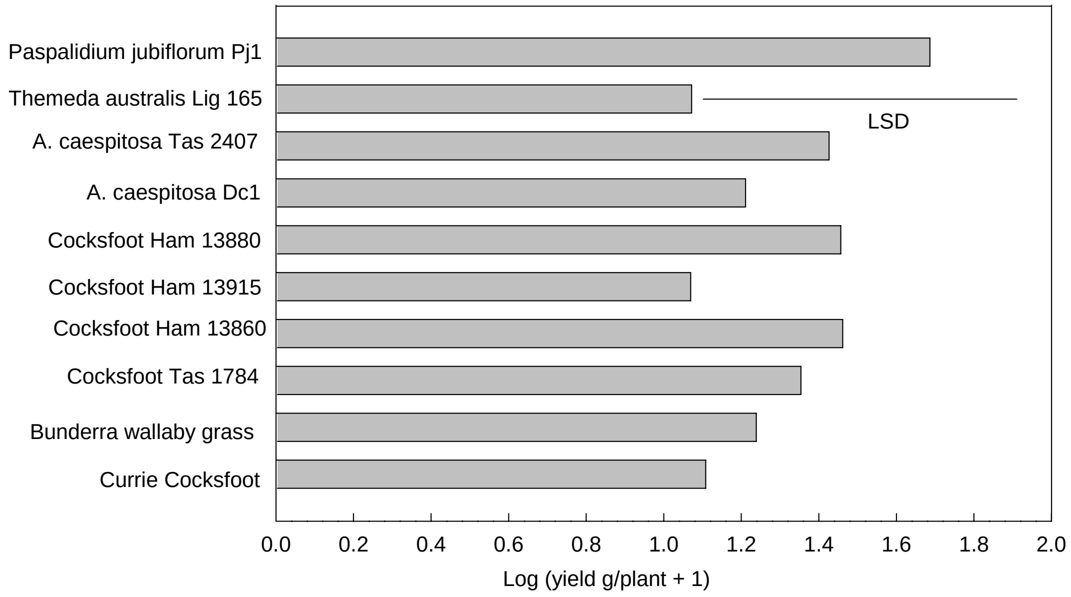
Figure 4.6.1 shows herbage production of all entries evaluated at the Binya site in September 1999. At this time, cocksfoot F066 was the most impressive grass. Early winter yields from July 2000 are presented in Figure 4.6.2. Both native C_4 and C_3 species (e.g. *Paspalidium jubiflorum*, *Austrodanthonia caespitosa* (2407, Dc1), Bunderra wallaby grass) and exotic C_3 cocksfoot lines (13880, 13860, 13915, 1784) performed well at that time. Two native C_4 grasses, *P. jubiflorum* and *Themeda australis* (Lig165) performed well early in that winter. However, this high production was possible because cold, frosty conditions arrived late in 2000 so that these frost tender C_4 species were able to continue growth longer into the autumn than is often possible. By this stage of the experiment, a number of accessions had virtually disappeared from the plots, including Wakefield and Shannon microlaena. Binya was probably too hot and dry for the survival of *Microlaena stipoides*.

Figure 4.6.1: Herbage yield of spaced plants of grasses tested at Binya, NSW in September 1999.



A number of cocksfoots did not perform as well as expected. It was observed that the establishment of these lines on weed matting seemed to raise the level at which the plants held buds necessary for regrowth after cutting, and it is suspected that these buds may have been unintentionally damaged when the plants were cut, subsequently causing plant death. Therefore, it is recommended that future evaluation of grasses such as cocksfoot should not occur on weed matting. The poor performance of Kasbah cocksfoot at Binya is noteworthy, particularly when compared to this cultivar’s high production on a more fertile soil at a site 25 km to the east (Norton *et al.* 2001).

Figure 4.6.2: Herbage yield of the ten most productive grasses at Binya, NSW in July 2000.



The harvest taken at the end of summer in March 2001 was the final herbage yield assessment of the experiment, and results of the most productive 50% of the test grasses are presented in Figure 4.6.3. Due to variability within the data at this time, C_4 grasses were analysed separately from C_3 species. *D. sericeum* was significantly more productive than all other C_4 species, with *T. australis* (Lig165) the next highest producer. Among the C_3 species, the most productive entries were from the genus *Austrodanthonia*, specifically cultivars Bunderra and Taranna. These 2 grasses were able to use the rainfall which fell in February and, being tolerant of low fertility conditions, were able to produce the highest yields of the C_3 species. *Elymus scaber* (Lig473) was the next most productive line, followed by *A. caespitosa* (Dc1) and cocksfoot (1795).

(b) Persistence

Plant survival near the end of the experiment is summarised in Table 4.6.3. Survival of most C_4 species, both of the natives and of the exotic Consol lovegrass, was high. Among the C_3 grasses, survival was variable. Some, such as Taranna and Bunderra wallaby grass, survived very well, while others (e.g. cocksfoots 13880 and 1784) had survival rates around 40%. Still others, such as Wakefield and Shannon microlaena and *Elymus scaber* (Es1) died out completely even before the drought of autumn 2001. These last 3 grasses originated from tableland environments and did not adapt to the drier, hotter plains. There was also substantial mortality (data not shown) between the last harvest date in March 2001 and the final population count which occurred 3 months later in June. The most severe drought conditions occurred during this period, resulting in much plant death and a decline in the rankings, particularly of the cocksfoot group and the sole surviving *E. scaber* (Lig473). However, Bunderra and Taranna wallaby grasses survived this period well.

(c) Other measurements

Little recruitment of sown grasses was noticed at this site, and no significant differences between accessions were observed (data not presented). It is probable that the high levels of Na and the high Ca/Mg ratio produced a surface soil structure which was self-sealing and hostile to the establishment of small seeded grasses.

It was not possible to assess the palatability of the grasses at the Binya site, as there was very little rain after the March 2001 harvest up till the time of termination of the experiment in June 2001. Consequently, there was not enough herbage production to make palatability assessment feasible.

Figure 4.6.3: Herbage yield of the top 50% of grasses tested at Binya, NSW in March 2001.

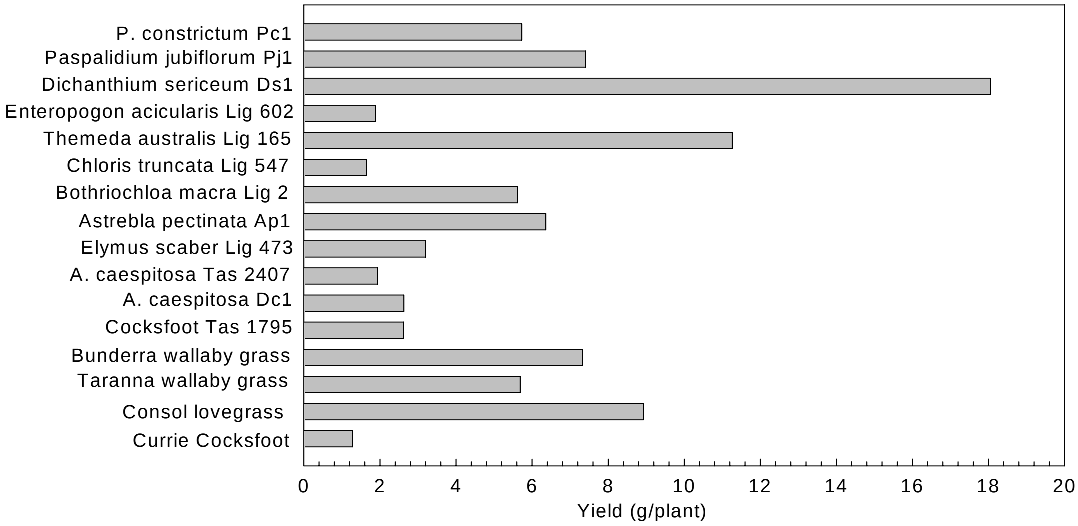


Table 4.6.3. Survival (proportion of original population) of accessions in June 2001 at Binya, NSW. Survival levels in the same column with different superscripts are significantly different ($P<0.05$)

Accession	Survival	Accession	Survival	Accession	Survival
Currie cocksfoot	0.32^{cd}	Cocksfoot 13860	0.16^{cde}	*E. scaber* Lig473	0.00^{e}
Consol lovegrass	1.00^{a}	Cocksfoot 13915	0.03^{de}	*Astrebla pectinata* Ap1	0.88^{a}
Taranna wallaby grass	1.00^{a}	Cocksfoot 13946	0.14^{cde}	*B. macra* Lig002	1.00^{a}
Bunderra wallaby grass	0.97^{a}	Cocksfoot 13880	0.41^{bc}	*C. truncata* Lig547	1.00^{a}
Wakefield microlaena	0.00^{e}	Cocksfoot 13932	0.07^{cde}	*T. australis* Lig165	1.00^{a}
Shannon microlaena	0.00^{e}	Cocksfoot 13942	0.00^{e}	*E. acicularis* Lig602	0.84^{ab}
Cocksfoot 2024	0.00^{e}	Cocksfoot F066	0.00^{e}	*D. sericeum* Ds1	0.95^{a}
Cocksfoot 1795	0.00^{e}	Cocksfoot P137	0.09^{cde}	*P. jubiflorum* Pj1	1.00^{a}
Cocksfoot 1703	0.09^{cde}	*A. caespitosa* Dc1	0.84^{ab}	*P. constrictum* Pc1	0.91^{a}
Cocksfoot 1784	0.36^{cd}	*A. caespitosa* 2407	0.32^{cd}	Kasbah Cocksfoot	0.00^{e}
Cocksfoot 1715	0.02^{de}	*Elymus scaber* Es1	0.00^{e}		

4.6.4 Recommendations

The best performing grasses at Binya, both in terms of herbage production and persistence were *Themeda australis* Lig165, Consol lovegrass and Bunderra wallaby grass.

4.7 Flaxley, SA

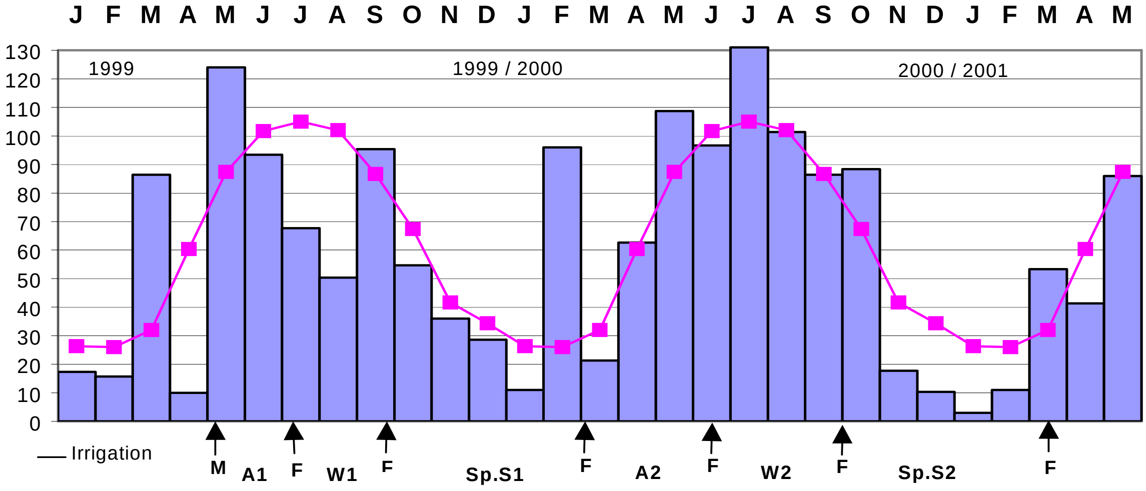
(E Kobelt, G Auricht, South Australian Research and Development Institute)

4.7.1 Site Description

(a) Location and Climate

Flaxley is located in the Adelaide Hills 33 km southeast of Adelaide, South Australia at an altitude of approx. 400m. Climate is mediterranean, January is the hottest and driest month while July is the coldest and wettest month. The mean annual rainfall at Flaxley is 808 mm. Mean monthly rainfall varies from 26mm in January to 105 mm in July as shown in Figure 4.7.1. Mean maximum and minimum temperatures at Flaxley are 27 and 12°C for January, and 13 and 4 °C for July.

Rainfall received at the Flaxley site during the experiment is shown in Figure 4.7.1. For the period during which measurements were taken (May 1999 to May 2001), rainfall overall was marginally below average (down by 6%). 1999 was generally drier, with the winter months being much drier than normal. In 2000, the period May to October was wetter than average, but the rain season ended abruptly and the summer of 2000/2001 was one of the hottest and driest on record.



Arrows indicate Dates of Forage cuts (F), and Weedmat removal and Mowing off (M).
Seasonal growth periods as measured by forage cuts are, A=Autumn, W=Winter, Sp.S=Spring-Summer.

(b) Soil and Soil Fertility

Soils in the Flaxley area are formed over a deeply weathered sandstone and are hard-setting and poorly structured. Soils are classified as kurosols or podzols. They are acid throughout, have moderate to poor drainage and a naturally low fertility. Due to the poorly structured surface layer, soil workability and seedling emergence are not good and erosion potential is moderate. Consequently, land use around Flaxley is predominantly livestock grazing on permanent pastures of annual and perennial mixtures.

Topsoil of the Flaxley NLIGN site is a greyish-brown fine sandy loam to 25 cm depth. Below is a light orange-brown mottled heavy clay to over 100 cm depth. The experimental site was formerly a weedy pasture with low fertiliser input, and is gently sloping but prone to sub-surface waterlogging in winter. Prior to cultivation,the site was sampled for soil analysis (Table 4.7.1). Results show low levels of P and K, while Na and Mg levels and pH are higher than usual due to a past history of irrigation in this paddock.

Table 4.7.1: Chemical analysis of soil (0-10 cm) at the Flaxley NLIGN site

pH	EC	C%	S%	N%	P	ECEC
5.98	0.44	3.43	0.03	0.29	11.6	15.32
Al	**Mn**	**Na**	**Mg**	**Ca**	**K**	**Units for cations**
0.01	0.02	1.46	2.98	7.10	0.58	cmol/kg
0.9	1.1	67	73	284	45	mg/kg

Legend and analytical methods

pH	1:5 soil/0.01M CaCl2 extraction.
EC	Electrical conductivity (dS/m), 1:5 soil/water extraction.
ECEC	Exchangeable cations (cmol/kg), BaCl2 /NH4Cl extraction, Flame AAS.
P	Olsen available P (mg/kg), spectrophotometer.
C, N, S	Total Carbon, Nitrogen & Sulphur, LECO CNS analyser.

4.7.2 Field operations

(a) Experimental design

The Flaxley experiment was designed with 32 entries and two replicates. Of the 32 entries 25 were C_3 grasses and 7 were C_4 grasses. Fifteen exotic lines were compared to 17 native lines. Sources of these lines were Tasmania 8 lines, LIGULE 6, NSW 5, SA 5, Victoria 1, and commercial cultivars 7. Protocols set down for the NLIGN project (Section 3) were generally followed, and any significant departures from the protocols are described below.

(b) Site preparation and planting

The site was soil sampled, sprayed, cultivated, and fenced during autumn 1998. Weedmat was laid and planting of glasshouse raised seedlings commenced in mid June with 25 C_3 grass lines. The area fenced was slightly smaller than required and plant spacing was reduced from 30 to 27 cm. The seven C_4 grass entries were first planted on 20th October. Establishment was very good (≅98%) with very few plants needing replacement. A light irrigation was given after both the October planting and the November replanting. All grass plants were mown to 6 cm height in late November. Over summer the experiment was irrigated several times to ensure establishment and survival. Irrigation ceased after good rainfall in March 1999. On 5th May, weedmat was removed and grass plants mown back to 4 cm height. *Chloris truncata* suffered some crown damage and tiller loss during weedmat removal because its crowns had rooted through the weedmat.

Because of toxicity and potential to escape, the original accessions 29 and 30 were removed from the experiment in November 1998 and replaced in 1999 with the two cocksfoot lines shown in Table 3.1. Weedmat was left on these 4 plots till plants were established (June 2000) and measurement began at this time. Because these two replacement lines were a year behind the other 30 lines and also retarded by lack of summer irrigation, yield comparison is difficult. Also, lack of flowering and weedmat presence prevented recruitment in 2000. Plants of a contaminant line found in *Paspalidium jubiflorum* plots were removed in December 1999 prior to seed set, so instead of 16 plants for measurement, the 2 replicates of these plots had 9 and 10 plants each.

(c) **Management**

No fertiliser was applied in this experiment. For the duration of the experiment, the surrounding paddock was strip grazed by dairy cows. On two occasions one or two cows entered the experiment and had short spells of selective grazing. These grazings were scored and estimated % grazed was used to adjust yields. In most cases the % grazed was nil to very low. These assessments complement palatability scores taken after controlled grazing by sheep in May 2001.

4.7.3 Grass performance

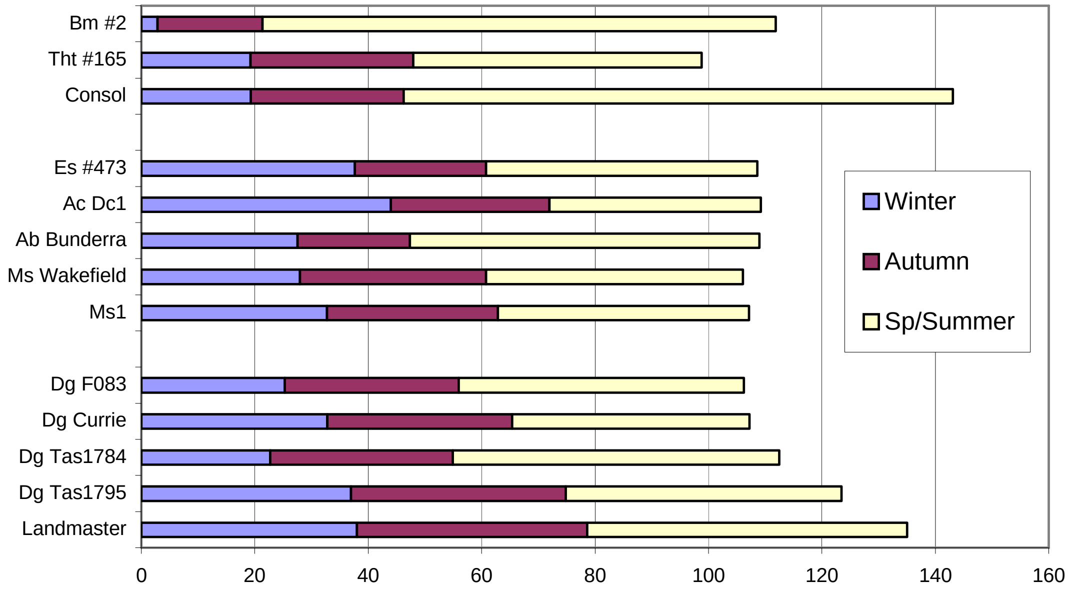
(a) **Herbage production**

Dates of harvests and seasonal harvest codes (as shown in Figure 4.7.1) were: 7 July (A1) and 23 September (W1) 1999; 1 March (S1), 15 June (A2) and 29 September (W2) 2000; and 13 March 2001 (S2). The first 3 cuts measured 43 weeks growth (from 5/5/99), and the last 3 cuts 53 weeks growth. In accordance with the diversity of material tested, yields at Flaxley differed dramatically in total yield and in seasonal and yearly growth patterns. In subsequent discussions, yield (unless specified otherwise) is the total of all 6 forage cuts and seasonal yields refer to the season of growth harvested rather than the time of harvest (e.g. autumn yield is the forage which grew during autumn and was harvested in early winter).

(i) Total Yield

Yields ranged from 27 to 143 grams per plant (gpp) for 22 months of growth, which equates to 2.0 to 10.7 t/ha/yr. The experiment average was 90 gpp or 6.7 t/ha/yr. Figure 4.7.2 shows the total yield for 13 of the 16 top yielding lines, with yield partitioned into seasonal totals and the lines grouped (C_4, native, exotic). The three lines omitted in Figure 4.7.2 are all cocksfoot lines (2024, 13939 and F066), with yields of 107,102, and 100 gpp respectively. The top 16 yielding lines include 5 commercial cultivars, 5 native lines, and 6 exotic lines. Overall, the C_4 grasses performed no better or worse than C_3 lines, with three C_4 grass lines in the top 16. Taranna wallaby grass and Shannon microlaena yielded 91 and 90 gpp respectively. Of the two replacement cocksfoot lines, P137 had the greater yield (42.2 gpp). This compares well over the same 12 month period with Currie (43.8 gpp), which was a year more advanced.

Figure 4.7.2: Total and seasonal yields of the 13 highest yielding lines at Flaxley



(ii) Seasonal Yield

Large differences in seasonal growth patterns were obvious and are shown by the seasonal yield totals in Figure 4.7.2. *Bothriochloa macra* typified the C_4 grasses, which generally had low autumn and very low winter yields. Spring-summer accounted for 50-80% of C_4 grass yields, except for *Chloris truncata* (37%) and *Enteropogon acicularis* (45%) which had much lower warm season yields. Consol lovegrass and *Themeda australis* (Lig165) had considerably higher cool season yields than the other C_4 lines (e.g. *B. macra*).

Most C_3 grasses followed a 30/30/40% pattern for winter/autumn/spring-summer yields. The C_3 grasses which deviated most from this pattern were *Austrodanthonia caespitosa* (Dc1) (40/26/34%), the cocksfoots 13939 (37/28/35), 1703 (24/23/53), 1784 (20/29/51) and F083 (24/29/47), and Bunderra (25/18/57) and Taranna (25/24/51%) wallaby grasses.

The experiment grand mean of 50.7 gpp over 43 weeks in year 1 dropped to 39.7 gpp over 53 weeks in year 2. Averages for the 6 cuts (A1, A2, W1, W2, S1, S2) were 11.9, 12.4, 11.4, 11.5, 27.5 and 15.8 gpp respectively. The much lower second summer yield (S2) corresponds with a very dry and hot summer. The best performing lines for this S2 period defied this trend and had higher yields than the first summer. These lines and their yields were: *B. macra* (46), Consol lovegrass (45), *P. jubiflorum* (38) and *T. australis* Lig165 (27 gpp). These 4 lines are all C_4 grasses. Other lines that had good production in the second summer were Bunderra wallaby grass (25), cocksfoot 1784 (24) and Landmaster phalaris (24 gpp). The very poor second year yield of *A. caespitosa* 2407 (17.9 gpp. *vs* 53.9 in year 1) resulted from low yields in all 3 seasons (A2 4.5, W2 7.9, S2 4.5 gpp), associated with very dense and productive seedlings recruited early in year 2 (see recruitment below).

(b) **Persistence**

Plant counts were taken in May and September 1999 and 2000, and finally in May 2001. Most of the test lines had good or very good persistence. At the final plant count at May

2001, 8 lines still had 16 original plants in both replicates. A further 13 lines had mean plant counts of 14.5 to 15.5 that were not significantly lower than 16. This group of 21 most persistent lines included 12 of the 16 top yielding lines.

Only 11 lines showed significant plant loss. Six lines had good to moderate persistence losing 2.5 to 6 plants per plot and included cocksfoot 1795 (13.5) and F066 (13), both of which were high yielding lines. Five lines had poor persistence, included two high yielding lines (cocksfoot 2024 and *Elymus scaber* Lig473) with mean counts of 7.5 and 5.5 respectively. All three lines of *Elymus* spp. had very poor persistence. Most plant deaths occurred between September 2000 and May 2001. Only the three *Elymus* lines (Es1, Lig473 and Tas1143) lost two or more plants per plot by September 2000, but in the next 8 months lost a further 6, 7.5 and 10 plants respectively.

(i) Recruitment

Seedling recruitment was measured in October 2000 and May 2001. Late weedmat removal, mowing, poor and unequal seedset and bare hard ground prevented recruitment in 1999. Good germinations occurred in 2000 after heavy late February rainfalls and an early season break. This recruitment was measured by counts in October 2000. Further germination occurred in autumn 2001. Another quadrat count in late May 2001 measured presence of seedlings from <u>both</u> years of germination and the proportions of new and old seedlings were noted.

Mean recruitment counts are presented in Figure 4.7.3 for a selected group of higher yielding lines. Seedling recruitment varied from near zero to near the maximum of 81 possible quadrat cells per plot. With a few notable exceptions, recruitment at the Flaxley site can be summarised by three scenarios described below. Lines shown in Figure 4.7.3 are marked with an asterisk.

(ii) C4 grasses

These germinated in 2000 after favourable and unseasonal late summer rains and survived the following dry summer to be counted again in May 2001. However, there was little or no germination in autumn 2001, and most or all seedlings at the May 2001 sampling were ones which had germinated in 2000. *P. jubiflorum* and *T. australis** (Lig165) both recruited poorly, while *B. macra** and *C. truncata* recruited very well.

(iii) Native C3 grasses

These recruited well or very well in 2000 and also had good survival over the summer. All *Microlaena stipoides* lines (e.g. Ms1*) and both *A. caespitosa* lines (2407, Dc1*) had exceptionally high seedling establishment in 2000, resulting in some mortality in late summer and few new seedlings being observed in 2001. *A. caespitosa* (2407) seedlings were very dense and productive. Yield of these seedlings was measured at the winter 2000 forage harvest, with seedlings yielding 2.9 t/ha compared to 1.0 t/ha for the cohabiting parent plants. Bunderra* and Taranna wallaby grasses, and *Elymus scaber* (Es1 and Lig473) had lower but adequate recruitment.

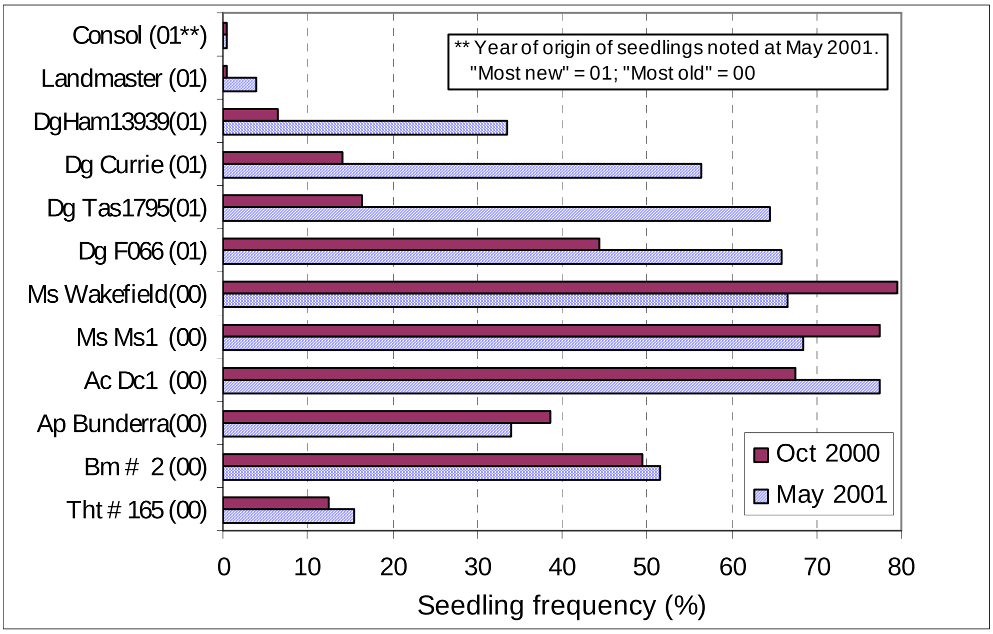
(iv) Exotic C3 grasses

These had low to moderate recruitment in 2000, but relatively few (approx. 5-10%) seedlings survived the dry summer period. *Festuca ovina* had no seedlings survive. Recruitment in 2001 was much higher than 2000. Of the cocksfoot lines, 13939* had the lowest recruitment (both years), and Currie*, 1784 and 1795* were low in 2000. However, F066*, F083, F146 and 2024 had moderate to good recruitment in 2000, with some surviving old seedlings at May 2001.

(v) Exceptions

Elymus trachycaulus did not flower at all at Flaxley Enteropogon acicularis had very low recruitment both inside and outside its plots, though was readily invaded by seedlings of other lines. Very low recruitment was recorded for Landmaster phalaris* and Consol lovegrass*, both of which only germinated freely outside their plots and had no invasion by weeds or other lines.

Figure 4.7.3: Recruitment of high yielding lines at Flaxley, spring 2000 and autumn 2001.



(c) **Palatability/Animal Preference**

Palatability was assessed on 3 occasions, twice accidentally by cows in early July and early December 2000, and once intentionally in May 2001 with sheep as per protocols. Accidental grazings were short in duration with only the most palatable lines eaten, while the intentional grazing was for 4 days, ending with all lines grazed. In May 2001 there was much less feed on offer and the weather was wet and windy during grazing. This may have favoured grazing of taller erect lines in preference to prostrate lines which were dirtied by rain splash.

(i) *C_3 grasses*

On all three occasions, Landmaster phalaris was the most palatable of all lines tested, particularly in December 2000 when it was heavily grazed (68%) while all other lines had no or only minor grazing (0-18%). In December 2000. *Elymus trachycaulus* and all the *M. stipoides* and cocksfoot lines had minor grazing, while all other C_3 grass lines (*Austrodanthonia, Elymus*) were completely ungrazed. The cocksfoot lines were less palatable than Landmaster phalaris and more palatable than *M. stipoides* lines, with grazing for these groups in July 2000 of 25-35%, 43%, 13-23%, and in May 2001 of 90-96%, 97% and 79-88% respectively. In both the July 2000 and May 2001 assessments, 1703 was the least palatable cocksfoot (25, 90%) and, of the 4 *M. stipoides* lines, 2402 was the least palatable (4, 79%; also most prostrate) and Wakefield the most palatable (23, 88%; and more erect). The erect *E. scaber* lines were unpalatable in December, May, and July (58,0,0% grazed).

(ii) *C_4 grasses*

All seven C_4 grass lines were the least grazed of all lines in both July 2000 and May 2001 (when not actively growing), while in December 2000 three (*B. macra, C. truncata, P. jubiflorum*) had minor grazing and the other 4 lines were ungrazed. In May 2001, the four most prostrate C_4 grasses were the least grazed (40-48%) while the erect Consol lovegrass, *T. australis* (Lig165) and *P. jubiflorum* were grazed more (63,63,73%).

Excluding C_4 grasses (which would be best assessed in spring), a broad ranking of accessions tested for palatability at Flaxley (most palatable first) is Landmaster, followed by cocksfoot and other exotic C_3 grasses, then the native grasses. Of the native grass lines, the most palatable were *M. stipoides* then *Austrodanthonia* spp., with the least palatable being *E. scaber*.

4.7.4 Conclusions

The Flaxley experiment has identified a group of 19 lines with good yield and persistence. Six native grasses had good performance in all measured attributes, including recruitment and seedling survival. *M. stipoides* (Ms1, Wakefield) and *A. caespitosa* (Dc1) were the highest yielding of these six, while lower but moderate yields were obtained from Shannon microlaena, Taranna wallaby grass and *A. fulva* (Lig179). The other thirteen lines had one or more deficiencies, either in recruitment or survival of seedlings and/or in poor cool season growth. Both Landmaster phalaris and Consol lovegrass had very low or zero recruitment. Bunderra wallaby grass, *T. australis* (Lig165) and Consol lovegrass have low cool season growth, while *B. macra* is also very slow growing in the cool months.

Eight cocksfoot lines (including Currie, 1784 and 1795) had high yield, good persistence and good cool season growth, but poor or very poor seedling survival over summer. Cocksfoot 13939 had good winter growth and persistence but poor recruitment, while F066 and 2024 had better recruitment and good winter growth, and F083 and F146 also had better recruitment.

Good cool season growth, and good recruitment and seedling survival are highly desirable traits for a summer dry environment like Flaxley. It was noted that very little recruitment or growth of weeds occurred in plots of Consol lovegrass, and to a lesser extent in Landmaster phalaris. The absence of seedlings or companion plants together with high persistence may indicate potential weediness. While most lines tested at Flaxley had good persistence for two years, continued monitoring is recommended to assess long term persistence. Further testing of the best performing NLIGN lines is recommended, including monitoring of seedling survival and yield assessment of established seedlings.

4.8 Albany, WA

(P Sanford, J Gladman, Agriculture Western Australia)

4.8.1 Site Description

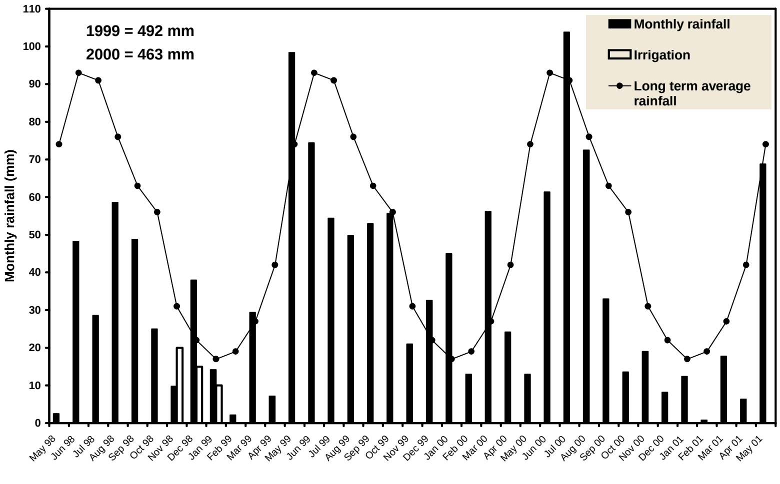
The Western Australian NLIGN site is located on a farm near Kendenup just north of Mt Barker in a long-term average rainfall zone of 600 mm. The site is near the top of a gentle slope facing north and was originally an annual pasture containing subterranean clover, ryegrass and broadleaf weeds such as capeweed. Soil measurements (0-10 cm) were taken on the 18th March 1998, and results were as follows:

Texture	Loamy sand over clay.
pH ($CaCl_2$)	4.8
EC	193 mS/m (0 – 200 non saline)
Available P	34 mg/kg
Organic carbon	6.79 %
Total N	0.47 %

4.8.2 Rainfall

Rainfall for the period of the experiment is presented in Figure 4.8.1. Both 1999 and 2000 were dry years in comparison to the long-term average. However 1999 was a much wetter year than 2000 with the summer of 1999/00 providing sufficient rain to stimulate plant growth. Spring 2000 through to autumn 2001 was one of the driest on record and had a significant impact on the results. The experiment was irrigated in late 1998 to ensure seedling survival under dry conditions (Figure 4.8.1).

Figure 4.8.1: Monthly rainfall, long-term average rainfall and irrigation at the NLIGN site at Kendenup, WA from May 1998 till May 2001 (mm).



4.8.3 Planting and management

Sep 98	Cool season (C_3) grasses transplanted from glasshouse
Nov 98	Warm season (C_4) grasses transplanted from glasshouse
Nov to Jan 99	Irrigation applied (see Figure 4.8.1)
Dec 98	Assessed for yield, survival and reproduction
Apr 99	Assessed for yield
Jun 99	Superphosphate applied at 75 kg/ha
Aug 99	Losses replaced with new transplants
Sep 99	Weedmat removed
Sep 99	Assessed for yield, survival and reproduction
Mar 00	Assessed for yield, leafiness, colour and survival
Jun 00	Assessed for yield, leafiness, colour, survival and reproduction
Jun 00	Superphosphate applied at 75 kg/ha
Oct 00	Assessed for yield, leafiness, colour, survival, reproduction and recruitment
Jan 01	Assessed for yield, leafiness, colour, survival and reproduction

4.8.4 Grass Performance

(a) Herbage production

The yields of the grasses in this experiment are summarised in Table 4.8.1. The overall ranking provides a good indication of grasses that performed well at this site. Consol Lovegrass (*Eragrostis curvula*) was ranked first and consistently outyielded most other accessions. This warm season C_4 grass was also able to outyield cool season C_3 grasses in winter (eg winter 2000). The next most highly ranked accessions were *Themeda australis* (Lig165), Taranna wallaby grass, *Austrodanthonia fulva* (Lig179) and *Microlaena stipoides* (Ms1), all of which are Australian native species. These grasses have been previously identified as having potential for pastures in southern Australia so it is not surprising to see them yielding well at this site. In this experiment, they outperformed Triumph fescue (ranked 6th), the best performing cool season perennial grass in the local area. Making up the top ten were Wakefield microlaena, cocksfoot 1795, Landmaster phalaris and Bunderra wallaby grass.

Overall, the cocksfoot lines did not perform well, with only one in the top ten and most ranked between 12 and 21. This suggests that rainfall at this site during the experiment was marginal for cocksfoot, which requires between 500 and 750 mm per year. In fact the rainfall was most likely marginal for both tall fescue and phalaris. Many of the newer cocksfoot accessions did however outperform the reference line (Currie) which was ranked 20th. This cultivar has been tested locally in a cattle grazing trial and reduced the need for supplementary feeding due to its ability to extend the growing season. On this basis, the best ranked cocksfoot accession (1795 - 8th) may be a better alternative to cv. Currie on the south coast of WA, particularly given its superior summer activity.

Landmaster phalaris (ranked 9th) yielded well in this experiment, particularly in winter, although as expected, it was dormant for most of the summer period. Historically, trials in this area have tested Sirosa phalaris and, while not conclusive, this result suggests that Landmaster could be superior in terms of dry matter production.

The remaining grasses in the experiment can be broken into two groups, those that persisted but were unproductive due to soil and climatic constraints (e.g. *A. caespitosa* 2407) or those that were unable to survive due to unknown factors (e.g. *Elymus scaber* Lig473). Amongst this latter group are grasses that yielded well in particular seasons and/or years. For example, *Chloris truncata* grew well in the wet summer of 1999/00 but failed to grow at all in the dry summer of 2000/01. Likewise, *Enteropogon acicularis* and *Paspalidium constrictum* , both warm season grasses, did well in summer but poorly in winter and spring. It is also likely that a number of the native grasses found the soil at the site too fertile and the climate too cool and wet. *E. acicularis* for example typically grows on infertile soils in the hotter and drier parts of Western Australia.

The results from this site are in general agreement with the literature. Native grasses were slow to establish but performed well under conditions of moisture stress compared to the commonly grown exotic species such as cocksfoot and phalaris. It is possible that native grasses would be superior in the less than 500 mm rainfall zone of the south west of WA, while above 500 mm, the reverse could be true. Further work should include evaluation of native grasses in the lower rainfall areas of southwest WA.

(b) **Persistence**

The proportion of plants that survived until the summer of 2000/01 is shown in Figure 4.8.2. Due to the dry spring and summer (Figure 4.8.1) a number of species may have been dormant at the time of the assessment. Many of the most productive accessions also persisted well, including Consol lovegrass, *T. australis*, Taranna and Bunderra wallaby grass, *A. fulva* (Lig179) and Triumph fescue. The persistence of the high yielding *M. stipoides* accessions (Ms1 and Wakefield) was low. However, based on the previous assessment in spring 2000, it seems that many of the plants had retreated to dormant buds by the summer of 2000/01 due to the dry conditions.

Table 4.8.1: Predicted yield (g/plant) and rank of grass lines in the NLIGN experiment at Kendenup WA from spring 1999 until summer 2000/01.

Species	Accession	Spring 99		Summer 99/00		Winter 2000		Spring 2000		Summer 00/01		Overall rank
		Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank	
Eragrostis curvula	Consol	48.15	11	40.05	1	18.16	1	16.91	2	6.47	1	1
Themeda australis	Lig 165	25.19	22	32.24	3	10.17	2	12.81	6	2.86	4	2
Austrodanthonia richardsonii	Taranna	36.61	17	28.70	6	7.06	10	7.12	13	1.63	8	3
Austrodanthonia fulva	Lig 179	44.33	14	29.92	5	7.16	9	7.15	12	1.05	14	4
Microlaena stipoides	Ms1	41.93	15	20.26	15	9.60	4	8.15	11			5
Festuca arundinacea	Au Triumph	69.29	7	32.54	2	5.51	20	9.39	9			6
Microlaena stipoides	Wakefield	36.31	18	25.28	10	6.46	13	9.39	10			7
Dactylis glomerata	Tas 1795	57.28	8	26.74	8	6.15	14	6.85	15	1.64	7	8
Phalaris aquatica	Landmaster	41.89	16	16.07	21	7.37	8	14.77	5			9
Austrodanthonia bipartita	Bundera	45.08	13	32.03	4	5.07	22	15.45	4	0.66	17	10
Enteropogon acicularis	Lig 602	5.82	31	20.36	13	9.43	5	2.47	26	3.05	3	11
Dactylis glomerata	F146	56.91	9	16.70	19	8.09	6	7.01	14	1.16	13	12
Austrodanthonia caespitosa	Dcl	0.00	35	17.15	18	5.80	17	17.53	1	0.37	20	13
Dactylis glomerata	Tas 2024	69.56	6	26.72	9	5.86	16	4.13	23	1.59	9	14
Dactylis glomerata	F066	106.92	1	14.87	24	6.10	15	6.76	16	1.81	6	15
Dactylis glomerata	Tas 1703	47.90	12	17.80	16	5.13	21	5.81	20	1.82	5	16
Paspalidium constictum	Pc1	14.28	26	22.25	12	4.22	23	2.70	25	4.25	2	17
Dactylis glomerata	Tas 1784	73.42	5	15.80	22	6.73	12	5.11	22	1.38	10	18
Dactylis glomerata	13939	82.85	3	8.08	32	6.98	11	11.23	7			19
Dactylis glomerata	Currie	89.62	2	15.46	23	5.68	18	9.40	8	0.49	18	20
Dactylis glomerata	F083	78.46	4	13.68	27	7.79	7	6.26	18	1.03	15	21
Microlaena stipoides	Shannon	18.57	24	23.78	11	5.64	19	5.28	21			22
Festuca ovina	Tas 829	48.53	10	7.73	33	9.73	3	5.88	19			23
Chloris truncata	Lig 547	33.07	20	27.87	7	3.41	24	0.71	31			24
Dicanthium sericeum	Ds1	11.52	27	20.32	14	2.75	26			0.13	22	25
Bromus macranthos	Tas 36	34.26	19	14.08	26	0.07	36	15.87	3			26
Austrodanthonia caespitosa	Tas 2407	7.95	29	6.17	34	1.98	29	6.28	17	1.28	12	27
Bromus bieberstienii	Tas 27	14.69	25	11.20	28	2.56	27	1.86	27	1.29	11	28
Bothriochloa macra	Lig 2	3.76	32	17.21	17	1.53	32	3.64	24	0.19	21	29
Dactylis glomerata	P137	0.00	34	14.29	25	0.76	33	1.45	29	0.37	19	30
Bromus mango	Tas 2048	29.49	21	16.56	20	2.35	28	0.41	32			31
Elymus scaber	Es1	2.75	33	8.46	31	0.44	35	0.85	30	1.02	16	32
Elymus trachycaulus	Tas 1143	10.04	28	10.57	29	1.62	30					33
Bromus mango	Tas 1424	24.95	23	9.50	30	1.59	31					34
Elymus scaber	Lig 473	7.60	30	2.78	36	2.95	25	0.19	33			35

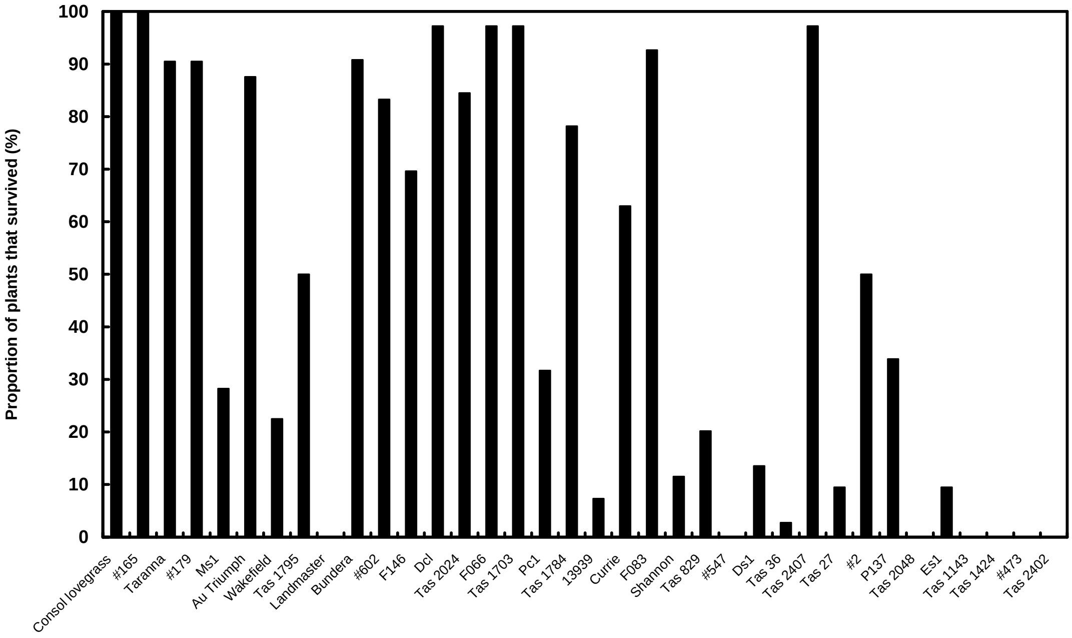
Microlaena stipoides	Tas 2402	0.00	36	3.98	35	0.52	34	1.50	28			36
LSD (*P* 0.05)		30.82		9.78		4.74						

Overall, the persistence of cocksfoot lines was good. However, the highest yielding cocksfoot line (1795) was one of the least persistent - only 50% of plants survived. Clearly, the remaining plants increased in crown size and tiller number and, in so doing, outyielded the most persistent cocksfoot lines such as 2407.

At the time that persistence was assessed in the summer of 2000/01, Landmaster phalaris was dormant, and its survival rate in Figure 4.8.2 is shown as zero. In the previous spring, 97% of the phalaris plants transplanted had survived and it is reasonable to expect that a good number of these would have remained alive until the break of season 2001.

A number of the native grass accessions persisted poorly, for example *Elymus scaber*. While it is difficult to determine the reasons for poor persistence for each individual grass, in the case of the natives, it could be due to the high fertility of the soil or the cool, wet winter.

Figure 4.8.2. Proportion of original plants planted that survived until the summer of 2000/01 at the NLIGN site at Kendenup WA. Note accessions are ordered from left to right according to overall yield rank (see Table 4.8.1).



(c) Recruitment

There was no recruitment of native grasses in any of the experimental plots. The most frequent recruiter was cocksfoot followed by phalaris. Contrary to expectations, there was no recruitment of Consol lovegrass seedlings in the plots and very few in the buffer zone between plots. Annual ryegrass and brome grass also recruited in the plots via seed from the pasture surrounding the experiment.

4.8.5 Conclusions

Overall, the cocksfoot lines did not perform well in this experiment. However one line (Tas 1795) was ranked in the top ten performing accessions. This line, if commercialised, could be introduced into farmer demonstrations and tested under grazing for animal production. Based on the performance of Landmaster phalaris in this experiment, it should be recommended to growers on the south coast of WA.

Consol lovegrass performed well at this site both in terms of persistence and production. Given its summer performance it is also likely to de-water soils and reduce groundwater recharge, a major objective of the WA salinity action plan. Consol should be progressed into grazing trials and farmer demonstrations to assess its animal production capability in southwest WA.

The native grasses kangaroo grass (*T. australis* Lig165), wallaby grasses (cvs. Taranna and Bunderra, and accession Lig179) and *M. stipoides* (accession Ms1 and cv. Wakefield) all performed well in this experiment and with further work, particularly in establishment, they could become valuable pasture species in south west WA, both for animal production and dewatering potential. In general, all the promising native grasses in this experiment need to be tested on alternative soils and in different rainfall zones before any firm conclusions are drawn, because of the lack of knowledge and experience of these grasses in WA. Suggested areas for future work with promising native and exotic accessions are shown in Table 4.8.2. These include establishment techniques, information on grazing management and animal production, and evaluation of lines on different soils and in different climatic zones.

Table 4.8.2: Suggested areas of future research for the top ten performing accessions in the NLIGN experiment at Kendenup, WA.

Accession	**Establishment techniques**	**Grazing management and animal production**	**Different soils and rainfall**
Consol lovegrass		44	
Themeda australis *(Lig165)*	44	4	44
Taranna wallaby grass	44	4	44
Austrodanthonia fulva (Lig179)	44	4	44
Microlaena stipoides (Ms1)	44	4	44
Triumph fescue			
Wakefield microlaena	44	4	44
Cocksfoot (1795)		4	
Landmaster phalaris			
Bunderra wallaby grass	44	4	44

5. ACROSS-SITE ANALYSES

The testing of a group of the same cultivars under the one protocol across a range of environments substantially broadens the knowledge of cultivar performance. This project has evaluated different grass genotypes at 8 sites across 3 different ago-ecological zones (Figure 3.1). The testing sites covered such divergent regions, that within each of these agro-ecological zones, the number of common accessions tested was maximised to strengthen across-site analyses. The 3 agro-ecological groupings of sites were Eastern Australian permanent pasture, Eastern Australian dry mixed farming and Mediterranean. Discussion of across-site performance of the test genotypes will therefore occur within the context of these groups.

Some inconsistencies do occur between individual site reports and across-site analyses. This is because only accessions which occurred at all sites within the group and where sufficient common samplings occurred were analysed. Thus, an individual accession which performed well at a particular site may not be mentioned in the across-site analysis because it did not have supporting information from other sites. However, these instances are considered in final recommendations.

5.1 Eastern Australia Permanent Pasture Zone

Mean yields of single spaced plants were analysed for 4 consecutive harvests across sites at Armidale, Canberra, Rutherglen and Jericho. The results of the analyses are presented in biplot format for summer 1999/2000, winter 2000, spring 2000 and summer 2000/01 (Figures 5.1.1 and 5.1.2).

During the summer of 1999/2000 the three cocksfoots, 2024, F066 and 1784 were high yielding accessions across the 4 sites, and 1795 performed well at all sites except Armidale. (Figure 5.1.1). Performance among the other genotypes tended to be less uniform so that, for example, whereas Landmaster phalaris produced highly at Armidale it was unproductive at Rutherglen, Canberra and Jericho. Similarly, *Elymus scaber* (Lig473) produced well at Canberra and Jericho but was much less productive at Rutherglen and Armidale. A number of varieties were uniformly unproductive across all 4 sites, including both *Austrodanthonia caespitosa* lines (Dc1 and 2407), cocksfoots Currie and 1703, and *A. racemosa*.

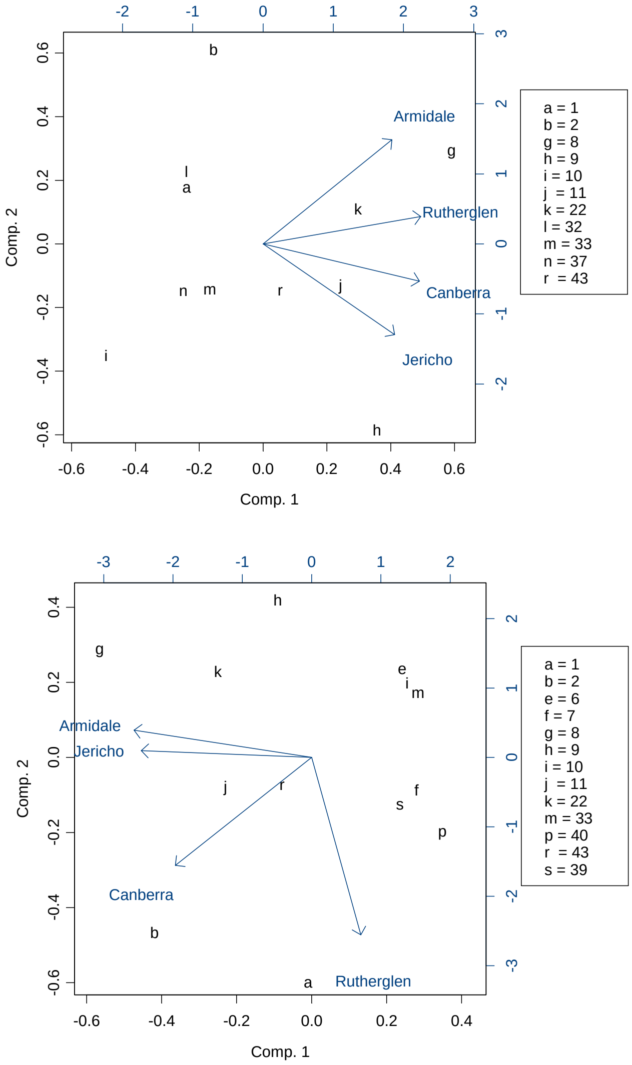
Greater differentiation of genotype production was evident in the results of winter 2000 than those of the previous summer. Genotypes performed similarly at Jericho and Armidale whereas the performance was unique at Canberra and Rutherglen (Figure 5.1.1). Landmaster phalaris was the most consistently high producing line at the 4 sites, followed by cocksfoot 1874 and *Elymus scaber* Lig473. In contrast, Currie cocksfoot performed well at Rutherglen and Canberra but had only moderate production at Jericho and Armidale. Similarly cocksfoots F066 and 1795, while producing well at Armidale and Jericho were only moderately productive at Canberra and low at Rutherglen. Three lines were uniformly unproductive across the 4 sites and these comprised Wakefield microlaena, cocksfoot 1703 and *A. caespitosa* (Dcl). A number of *Microlaena stipoides* lines were productive at Rutherglen including cv. Shannon, Lig183 and 2402, but were unproductive at the other 3 sites.

Production results for the spring of 2000 are presented in Figure 5.1.2. In this season the performance of genotypes at Jericho and Armidale was similar to that of the previous season (Figure 5.1.1). The performance of lines was however substantially different at Rutherglen. The genotypes with the highest production across the 4 sites included the cocksfoots Currie, 1795 and 1784 and Landmaster phalaris. Cocksfoot 2024 was also productive at all sites except Rutherglen, where it was only moderate yielding. Cocksfoot F066 and *E. scaber* (Lig473) were high yielding at Canberra, Jericho and Armidale but low yielding at Rutherglen.

In contrast, *Microlaena, stipoides* cvv. Shannon, Wakefield and Lig183, *A. racemosa*, and cocksfoot 1703 yielded well at Rutherglen but poorly at the other sites. The other accessions, including *A. caespitosa* (2407 and Dc1), *A. fulva* (Lig179), Taranna and Bunderra wallaby grass and *E. scaber* (Es1) produced only at low to moderate levels at all 4 sites.

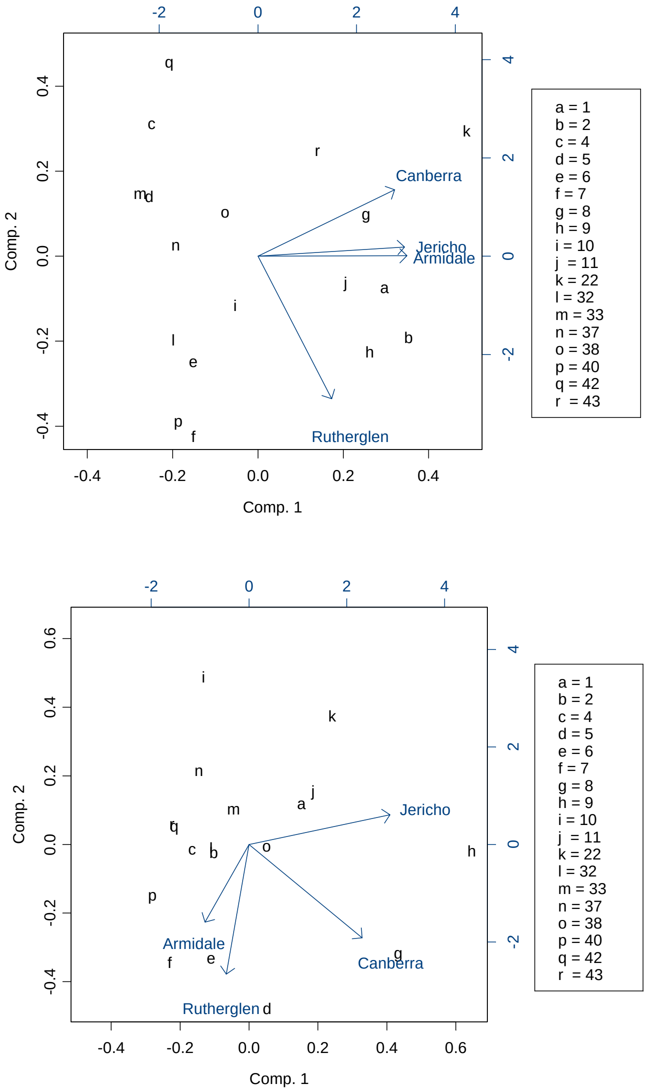
Yield results from the summer of 2000/01 are also presented in Figure 5.1.2. In contrast to the previous 2 seasons, many genotypes showed little similarity in performance at Jericho and Armidale. Many genotypes performed similarly at Armidale and Rutherglen, while production at Jericho was quite different to that at the other 3 sites.

Figure 5.1.1: Biplots of the first 2 principal components of herbage yield from results at Armidale, Canberra, Rutherglen and Jericho in Summer 1999/2000 (Upper) and Winter 2000 (Lower). Accessions are (a) Currie cocksfoot, (b) Landmaster phalaris, (e) Wakefield and (f) Shannon microlaena, cocksfoots (g) 2024, (h) 1795, (i) 1703, (j) 1784 and (k) F066, (m) *A. caespitosa* (Dc1), (p) *M. stipoides* (Lig183), (r) *E. scaber* (Lig473) and (s) *M. stipoides* (2402).



High producing lines at Canberra, Armidale and Rutherglen in summer 2000/01 included Bunderra wallaby grass, *M. stipoides* (Wakefield, Shannon and Lig183) and cocksfoot 2024 (Figure 5.1.2). Lines that produced highly at Jericho and Canberra included the cocksfoots 1795 and 2024. Three other cocksfoot genotypes, Currie, 1784 and F066 were highly productive at Jericho but only moderate at Canberra, and unproductive at Armidale and Rutherglen. The *Austrodanthonia fulva* line, Lig179, had moderate production levels at all 4 sites. Four entries, *Elymus scaber* (Es1 and Lig473), Landmaster phalaris and Taranna wallaby grass were moderately productive at Armidale and Rutherglen but had low productivity at both Canberra and Jericho. *A. caespitosa* (Dc1 and 2407) and cocksfoot 1703 were unproductive at all 4 sites.

Figure 5.1.2: Biplots of the first 2 principal components of herbage yield from results at Armidale, Canberra, Rutherglen and Jericho in Spring 2000 (Upper) and Summer 2000/01 (Lower). Accessions are (a) Currie cocksfoot, (b) Landmaster phalaris, (c) Taranna and (d) Bunderra wallaby grass, (e) Wakefield and (f) Shannon microlaena, cocksfoots (g) 2024, (h) 1795, (i) 1703, (j) 1784 and (k) F066, (l) *A. racemosa*, (m) *A. caespitosa* (Dc1), (n) *A. caespitosa* (2407), (o) *A. fulva* (Lig179), (p) *M. stipoides* (Lig183), (q) *E. scaber* (Es1) and (r) *E. scaber* (Lig473).

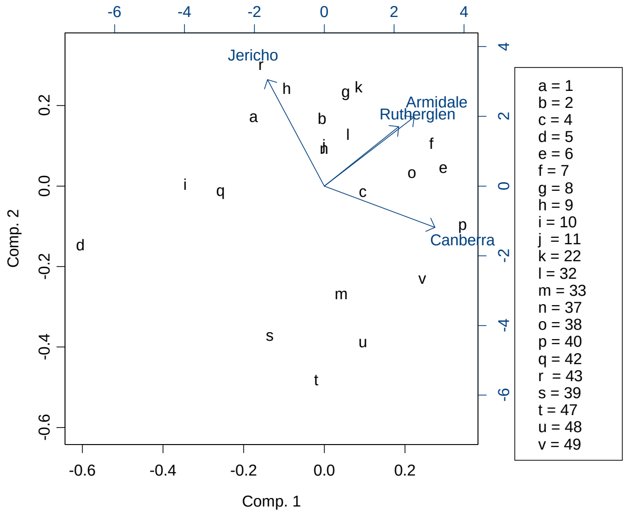


The results of final plant population (spaced plant survival/persistence) at Armidale, Canberra, Rutherglen and Jericho are presented in biplot format in Figure 5.1.3. The biplot shows that the persistence of lines at Armidale and Rutherglen was very similar. On the other hand, accessions tended to persist very differently at Canberra compared to Jericho. All the Tasmanian cocksfoot lines except 1703 persisted well at Armidale and Rutherglen and these lines also persisted well (including 1703) at Jericho. All the *Microlaena* accessions persisted well at Armidale and Rutherglen except 2402. Likewise, all the *Austrodanthonia* entries persisted well at all sites, except Bunderra and *A. caespitosa* (Dc1). *Elymus scaber* had variable performance with Lig473 doing well but Es1 persisting poorly. The C_4 grasses *Bothriochloa macra* and *Chloris truncata* also persisted poorly.

Strong genotype-environment (GxE) interactions between the Canberra and Jericho sites were evident in the persistence of most entries. For example, virtually all of the cocksfoot lines persisted well at Jericho but poorly at Canberra. Similarly, while the 4 *Microlaena* entries performed well at Canberra they persisted poorly at Jericho. *Austrodanthonia* persistence was also quite contrasting between these 2 sites, except for *A. racemosa* and *A. caespitosa* (2407). There were strong GxE interactions for both *Elymus scaber* lines, with both persisting well at Canberra but poorly at Jericho.

Some marked differences in persistence were evident occasionally between Armidale/Rutherglen (at which lines generally acted similarly) and the other 2 sites. For example, Taranna wallaby grass and Wakefield and Shannon microlaena performed poorly at Jericho but well at the other 3 sites, whereas the opposite occurred with Bunderra wallaby grass.

Figure 5.1.3: Biplot of the first 2 principal components of final plant population from results at Armidale, Canberra, Rutherglen and Jericho in Autumn 2001. Accessions are (a) Currie cocksfoot, (b) Landmaster phalaris, (c) Taranna and (d) Bunderra wallaby grass, (e) Wakefield and (f) Shannon microlaena, cocksfoots (g) 2024, (h) 1795, (i) 1703, (j) 1784 and (k) F066, (l) *A. racemosa*, (m) *A. caespitosa* (Dc1), (n) *A. caespitosa* (2407), (o) *A. fulva* (Lig179), (p) *M. stipoides* (Lig183), (q) *E. scaber* (Es1), (r) *E. scaber* (Lig473), (s) *M. stipoides* (2402), (t) *B. macra*, (u) *C. truncata* and (v) *T. australis* (Lig165).



5.2 Eastern Australia Dry Mixed Farming Zone

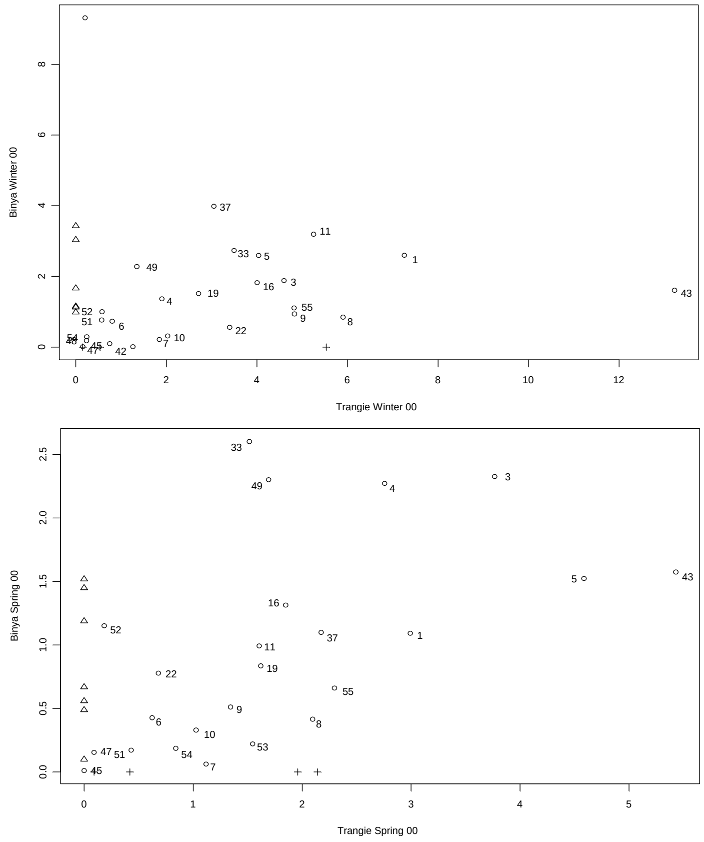
This zone was represented by sites at Trangie and Binya (Griffith). Results for 5 consecutive ‘end of season’ harvests together with final plant population (survival counts) were available for both sites. In spring 1999, 3 grasses performed well at both sites, the 2 cocksfoots Currie and 13932 and Bunderra wallaby grass. Some grasses performed well only at 1 site. At Binya, Shannon microlaena and cocksfoot F066 were productive, whereas at Trangie, high producers included Consol lovegrass, the cocksfoots Kasbah and 13915, *E. scaber* (Es1 and Lig473), and *T. australis* (Lig165).

T. australis (Lig165) and *Dichanthium sericeum* performed well at both sites over the summer of 1999/2000. Grasses which were productive only at Binya were Consol lovegrass, Bunderra wallaby grass, *Astrebla pectinata*, *B. macra* and *Paspalidium constrictum*. The only grass which was productive at Trangie at this time, but not at Binya, was *P. jubiflorum*.

Yield results from the winter and early spring harvests of 2000 are presented in figure 5.2.1. In winter 2000, cocksfoot 1784 was the only line with high production at both sites. Most other lines at Binya had low production at that time, except for *P. jubiflorum* and *A. caespitosa* (2407). A greater number of lines were productive at Trangie including *E. scaber* (Lig473), Consol lovegrass, Bunderra wallaby grass and a range of cocksfoots including Currie, Kasbah, 2024, 1795 and 13915.

In spring 2000, 4 accessions had high production at both sites, including Taranna and Bunderra wallaby grass, Consol lovegrass and *E. scaber* (Lig473) (Figure 5.2.1). While the majority of accessions had low productivity, 3 were quite productive at Binya, *T. australis* (Lig165), *A. caespitosa* (Dc1) and cocksfoot 13915. Currie cocksfoot was quite productive in spring 2000 at Trangie, but not at Binya.

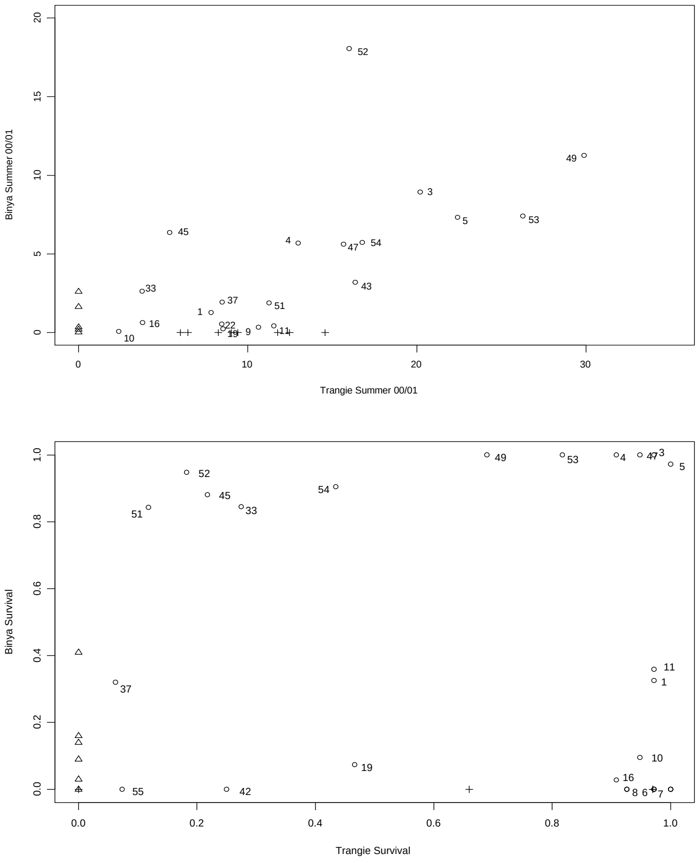
Figure 5.2.1: Herbage yield (g/plant) in Winter 2000 (Upper) and Spring 2000 (Lower) at Binya and Trangie. Accessions are (1) Currie cocksfoot, (3) Consol lovegrass, (4) Taranna and (5) Bunderra wallaby grass, (6) Wakefield and (7) Shannon microlaena, cocksfoots (8) 2024, (9) 1795, (10) 1703, (11) 1784, (16) 13915, (19) 13932 and (22) F066, (33) *A. caespitosa* Dc1, (37) *A. caespitosa* 2407, (42) E. scaber Es1, (43) E. scaber Lig473, (45), *Astrebla pectinata*, (47) *B. macra*, (48) *C. truncata*, (49) *T. australis* Lig165, (51) *Enteropogon acicularis*, (52) *Dichanthium sericeum*, (53) *P. jubiflorum*, (54) *P. constrictum*, and (55) Kasbah cocksfoot.



Results for the harvest taken at the end of the 2000/2001 summer for both sites are presented in Figure 5.2.2. At that harvest, only *Dichanthium sericeum* and *T. australis* (Lig165) were very productive at both sites. At Binya, apart from these 2, all other accessions were unproductive. At Trangie, a number of grasses were quite productive including *P. jubiflorum*, Consol lovegrass, Bunderra wallaby grass, *P. constrictum, B. macra* and *E scaber* (Lig473).

Survival of the original plants at the end of the experiments at both sites is also presented in Figure 5.2.2. Accessions with superior survival at both sites included Taranna and Bunderra wallaby grass, Consol lovegrass, *B. macra*, *P. jubiflorum* and *T. australis* (Lig165). There were a number of accessions which survived well at Trangie, but poorly at Binya, including Wakefield and Shannon microlaena and the cocksfoots Currie, 2024, 1703, 1784 and 13915. Similarly, there were accessions which survived well at Binya but poorly at Trangie, particularly *P. constrictum*, *A. caespitosa* (Dc1), *Astrebla pectinata*, *D. sericeum* and *Enteropogon acicularis*. Grasses exhibiting poor survival at both sites included the cocksfoots Kasbah and 13932, *E. scaber* (Es1) and *A. caespitosa* (2407).

Figure 5.2.2: Herbage yield (g/plant) in Summer 2000/01 (Upper) and final plant population (decimal proportion of survival) in Autumn 2001 (Lower) at Binya and Trangie, NSW. Accessions are (1) Currie cocksfoot, (3) Consol lovegrass, (4) Taranna and (5) Bunderra wallaby grass, (6) Wakefield and (7) Shannon microlaena, cocksfoots (8) 2024,(9) 1795, (10) 1703, (11) 1784, (16) 13915, (19) 13932 and (22) F066, (33) *A. caespitosa* Dc1, (37) *A. caespitosa* 2407, (42) *E. scaber* Es1, (43) *E. scaber* Lig473, (45) *Astrebla pectinata*, (47) *B. macra*, (48) *C. truncata*, (49) *T. australis* Lig165, (51) *Enteropogon acicularis*, (52) *D. sericeum*, (53) *P. jubiflorum*, (54) *P. constrictum*, and (55) Kasbah cocksfoot.



5.3 Mediterranean Pastoral Zone

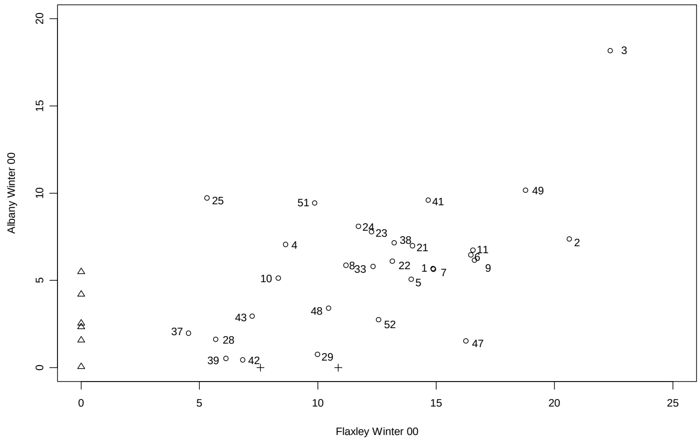
This zone is represented by sites at Flaxley, SA and Albany, WA. Results from 5 consecutive "end-of-season" harvests, Spring 1999, Summer 1999/2000, Winter 2000, Spring 2000 and Summer 2000/01 together with plant population figures at the termination of the trials were available for both sites.

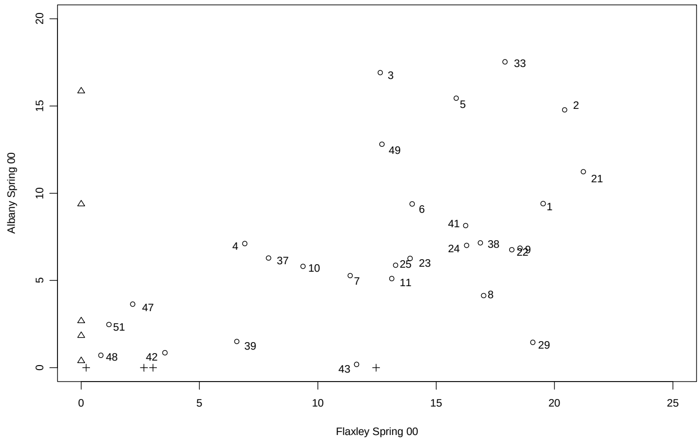
In spring 1999, 4 grasses were productive at both sites, although these were all cocksfoots (Currie, 2024, 1795 and 13939). A number of accessions were also productive only at 1 site. At Albany, cocksfoot was the only high producer and was represented by the accessions 1784, F066, F083, and F146. At Flaxley, grasses which performed well included Landmaster phalaris, Taranna wallaby grass, *M. stipoides* (Wakefield, Shannon and Ms1), *A. caespitosa* (Dc1 and 2407) and *Elymus scaber* (Es1 and Lig473).

In summer 1999/2000, the grasses which were productive at both sites included Consol lovegrass, Taranna and Bunderra wallaby grasses, *M. stipoides* (Wakefield, Shannon and Ms1) and the cocksfoots 2024 and 1795. As in spring 1999, a number of grasses were only productive at 1 site. At Albany, these included *A. fulva* (Lig179), *C. truncata*, *T. australis* (Lig165), *Enteropogon acicularis* and *D. sericeum*. At Flaxley productive accessions were the cocksfoots Currie, 1703, 1784, 13939, F066, F083, F146 and P137, Landmaster phalaris, *A. caespitosa* (Dc1 and 2407), *E. scaber* (Lig473) and *B. macra*.

In early winter 2000 (Figure 5.3.1) only Consol lovegrass and *T. australis* (Lig165) performed well at both sites. Production at Albany was particularly low at this time, with only these 2 accessions producing well. At Flaxley, a greater number of accessions were highly productive including Landmaster phalaris, cocksfoots 1795 and 1784, and Wakefield microlaena.

Figure 5.3.1: Herbage yield (g/plant) in Winter 2000 (Upper) and Spring 2000 (Lower) at Flaxley and Albany. Accessions are (1) Currie cocksfoot, (2) Landmaster phalaris, (3) Consol lovegrass, (4) Taranna and (5) Bunderra wallaby grass, (6) Wakefield and (7) Shannon microlaena, cocksfoots (8) 2024, (9) 1795, (10) 1703, (11) 1784, (21) 13939, (22) F066, (23) F083 and (24) F146, (25) *Festuca ovina*, (28) *Elymus trachycaulus*, (29) cocksfoot P137, (33) *A. caespitosa* Dc1, (37) *A. caespitosa* 2407, (38) *A. fulva* Lig179, (39) *M. stipoides* 2402, (41) *M. stipoides* Ms1, (42) *E. scaber* Es1, (43) *E. scaber* Lig473, (47) *B. macra*, (48) *C. truncata*, (49) *T. australis* Lig165, (51) *Enteropogon acicularis*, and (52) *D. sericeum*.

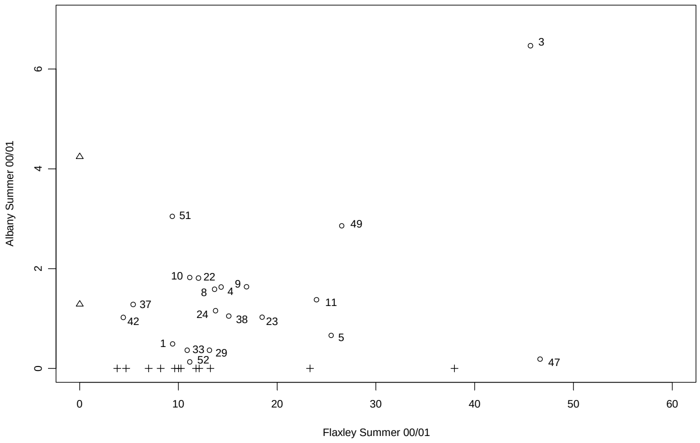


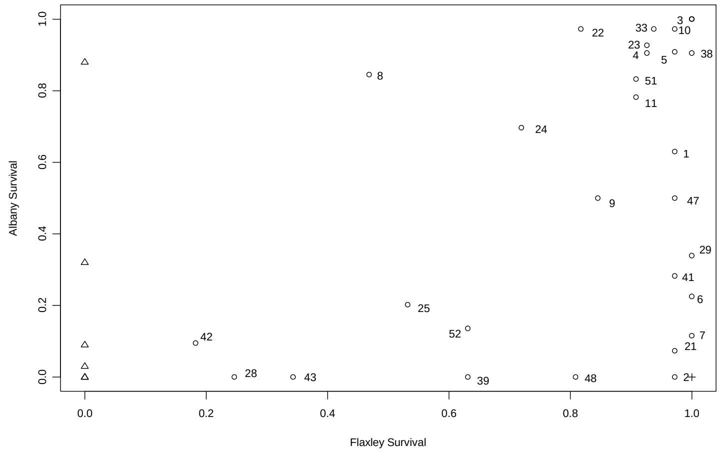


Results for herbage production in spring 2000 are also presented in Figure 5.3.1. Grasses which produced at a high level at both sites in this season included Landmaster phalaris, cocksfoot 13939, *A. caespitosa* (Dc1), Bunderra wallaby grass, Consol lovegrass and *T. australis* (Lig165). While there were no other grasses which were highly productive at Albany at this time, there were a number at Flaxley, the cocksfoots Currie, 1784, 1795, 2024, F066, F083 and P137, *Festuca ovina*, *A. fulva* (Lig179), *M. stipoides* (Wakefield and Ms1).

Production results from the end of summer 2000/01 are presented in Figure 5.3.2. Only Consol lovegrass had high production at both sites in this season, although overall productivity was much higher at Flaxley than at Albany. However, there were some accessions which were productive at one site only (e.g. *B. macra* at Flaxley and *Enteropogon acicularis* at Albany).

Figure 5.3.2: Herbage yield (g/plant) in Summer 2000/01 (Upper) and final plant population (decimal proportion of survival) in Autumn 2001 (Lower) at Flaxley and Albany. Accessions are (1) Currie cocksfoot, (2) Landmaster phalaris, (3) Consol lovegrass, (4) Taranna and (5) Bunderra wallaby grass, (6) Wakefield and (7) Shannon microlaena, cocksfoots (8) 2024, (9) 1795, (10) 1703, (11) 1784, (21) 13939, (22) F066, (23) F083 and (24) F146, (25) *Festuca ovina*, (28) *Elymus trachycaulus*, (29) cocksfoot P137, (33) *A. caespitosa* Dc1, (37) *A. caespitosa* 2407, (38) *A. fulva* Lig179, (39) *M. stipoides* 2402, (41) *M. stipoides* Ms1, (42) *E. scaber* Es1, (43) *E. scaber* Lig473, (47) *B. macra*, (48) *C. truncata*, (49) *T. australis* Lig165, (51) *Enteropogon acicularis*, and (52) *D. sericeum*.





Plant survival at Flaxley and Albany at the end of the experiments is also shown in Figure 5.3.2. Survival was generally higher at Flaxley than at Albany. Persistent grasses at both sites included Bunderra and Taranna wallaby grass, the cocksfoots Currie, F083, F066, F146, 1703 and 1784, *A. fulva* (Lig179), *Enteropogon. acicularis*, Consol lovegrass and *A. caespitosa* (Dc1). There were a number of grasses with high levels of survival at Flaxley but low levels at Albany. These included *Microlaena stipoides* (Wakefield, Shannon, Ms1 and 2402), cocksfoots 1795, 13939 and P137, Landmaster phalaris, *C. truncata*, *D. sericeum* and *B. macra*. In contrast, there was only one grass with high persistence at Albany but poor at Flaxley, cocksfoot 2024. Four entries had poor survival at both sites and these included *E. scaber* (Es1 and Lig473), *E. trachycaulus* (1143) and *Festuca ovina*.

6. SUCCESS IN ACHIEVING OBJECTIVES

The Native and Low Input Grasses Network has been successful in achieving its objectives:

- to assemble a set of low-input grass populations worthy of evaluation;
- to establish trial sites across southern Australia to evaluate these grass lines;
- to identify populations with the potential to be released as cultivars.

Well-conducted experiments with consistent protocols were conducted throughout southern Australia comparing a total of 58 exotic and native perennial grass lines. A minimum of 5 and a maximum of 25 of the tested accessions were recommended for further evaluation. Some of these will have wide application, while others will only be useful in certain environments, because of specific adaptations to climate and soils.

Extra R & D is necessary before any of the lines which have been identified by this first stage testing could be released as cultivars, but this project has successfully completed the first essential step in the process – the identification of well-adapted populations.

7. IMPACT ON MEAT AND LIVESTOCK INDUSTRY

We expect that new low input cultivars will be available to meat producers after completion of the necessary extra research in 3 to 5 years. Some of the recommended grasses (exotic lines) are already undergoing further evaluation and can attain commercial availability in a short period. However, we believe that additional research will be required for many of the native species to reach the same stage. Ultimately, however, the Pastoral Industry will benefit greatly from this project, as it has taken the first step in making available productive and persistent ‘low input’ grasses which will ensure more stable pastures and more sustainable animal production. This is particularly so in more difficult areas, which may have shallower, less-fertile soils, or where producers are unable to maintain adequate fertiliser inputs for pastures with exotic sown species.

8. CONCLUSIONS AND RECOMMENDATIONS

This project takes the view that a grass must be both highly persistent and capable of high levels of herbage production to warrant further evaluation toward cultivar development. It is also preferable that such plants have a high level of performance in both of these attributes at more than one site. Thus, there is considerable emphasis placed on the across-site analysis of herbage production and survival. Palatability was only measured at 3 of the 8 sites because of difficult seasonal conditions, and it has therefore not played any major role in shaping recommendations for development of future cultivars. However, this issue needs to be addressed, as suggested under Future research (8.4 below).

The ‘industry standard’ cultivars which were used as checks in the experiments (Currie cocksfoot, Landmaster phalaris, Consol lovegrass and Au Triumph tall fescue) are not the subject of recommendations here as these cultivars are already widely available. However, native grasses which have been released, but are not fully available because of lack of commercial quantities of seed (e.g. Taranna and Bunderra wallaby grass), are commented on.

8.1 Eastern Australian Permanent Pasture Zone

Analysis of the biplots of seasonal herbage production and survival at sites from within this zone indicates that 5 grass populations should be recommended for further development. These populations are the cocksfoots 2024, 1795 and 1784 (all from Tasmania), F066 from South Australia, and *Elymus scaber* 473 from the LIGULE program. The development of these accessions should be given top priority.

In addition to these accessions, collaborators from each of the sites have made recommendations of other lines which, in their opinion, warrant further development based on performance in their local environment (Table 8.1). In many cases, these accessions could not be incorporated in the across-site analysis, as they were not tested at all sites within a particular zone. Accessions which showed good performance at more than one site were *T. australis* (Lig165), Wakefield and Shannon microlaena, and both accessions of *A. fulva*.

8.2 Eastern Australian Dry Mixed Farming Zone

Themeda australis (Lig165) and Bunderra wallaby grass were the only new grass entries with sufficiently high performance in both production and persistence at both sites to merit more advanced evaluation and development. The impressive performance of Bunderra wallaby grass, which is still a newly released line, although commercially unavailable, should drive renewed efforts to solve the seed production problems of this cultivar to ensure sufficient quantities of reasonably priced seed are available. In addition to the above, local recommendations from collaborators at Trangie and Binya are shown in Table 8.1.

8.3 Mediterranean Pasture Zone

Bunderra wallaby grass was the only new grass in the across-site analysis to exhibit superior persistence and production at both Flaxley and Albany. However, the size of the zones in both Western and South Australia justify the additional recommendations in Table 8.1. made by the site collaborators. These grasses performed well at either Flaxley or Albany and should be the subject of further development in these environments.

8.4 Future research

Further research is required in the above environments with the recommended grasses, both those which performed well in the across-site analyses, and also those which performed well at individual sites. There is a need to continue a network similar to NLIGN and to expand it to ensure later stage testing of promising accessions is carried out. This will provide an on-going mechanism for the evaluation and release of pasture plants specifically tailored for use in adverse environments. The outcomes of this project have shown that some native grasses perform as well as their exotic counterparts, However, to capitalise on this, further research is needed in the following areas:

Longer-term persistence and production. Observations on plants in these experiments have only continued for 2½ years. Producers need to have confidence that sown plants will persist longer than this. Also, an issue raised by some collaborators is the potential survival and production of seedlings which recruit during the life of parent plants.

Animal preference/Quality. Climatic conditions unfortunately prevented palatability measurements at many sites in the present project. More information is required on whether plants are acceptable to animals, and on their leaf:stem ratios and nutritive values.

Establishment and seed production. A major constraint on the adoption of native cultivars is the lack of knowledge of establishment techniques, and the inability to easily produce sufficient seed to keep prices low. This must be overcome if such selections are to be successfully used as pasture plants.

General agronomy. There is a need to evaluate promising accessions under sward conditions rather than as spaced plants, and under grazing, prior to their commercialisation.

It is recommended that a new project be considered with three phases: (i) Initial plant screening; (ii) Establishment and sward evaluation; (iii) Seed increase. The well-tested procedures used in NLIGN could be retained for new material, and material recommended for further evaluation could enter stages (ii) and (iii).

There would be three main outcomes of the project. Firstly, the release of both exotic and native pasture cultivars for low input situations. Secondly, the development of guidelines for the field establishment of released native cultivars. Finally, the project would develop techniques for the production of sufficient quantities of seed of released cultivars for commercial seed production. This project would set in place an on-going assessment program, as well as providing a future mechanism for the release of new public and commercial cultivars specifically aimed at low-input situations.

The members of the NLIG network do not see a conflict with the testing of exotic introductions for higher input areas. The mechanisms for this are well established and should continue for situations where soil type, enterprise and product specifications dictate the use of high inputs to achieve maximum production. However, the group sees a role for low input species on more hostile areas of the landscape where enterprise requirements are less, and sustainability is a major issue. The suggested project is designed to build on the successes of the NLIGN project and create a mechanism for adequate testing of low input species.

Table 8.1: Species and accessions recommended for further evaluation and development in the NLIGN project (recommendations from across-site analysis and individual sites).

Species and accession	**Originating agency**	**Across-site analysis**	**Eastern Australian permanent pasture zone**				**Mixed farming zone**		**Mediterranean zone**	
			Armidale	Canberra	Rutherglen	Jericho	Binya	Trangie	Flaxley	Albany
Exotic lines										
D. glomerata (2024)	TIAR	✓	✓	✓	✓				✓	
D. glomerata (1795)	TIAR	✓				✓			✓	✓
D. glomerata (1784)	TIAR	✓							✓	
D. glomerata (F066)	SARDI	✓	✓	✓	✓				✓	
D. glomerata (F083)	SARDI				✓					
D. glomerata (F146)	SARDI		✓							
D. glomerata (13939)	DNRE, Vic								✓	
P. aquatica (AT96)	CSIRO			✓						
B. biebersteinii (27)	TIAR					✓				
Native lines										
A. richardsonii cv. Taranna	NSW Ag		✓				✓		✓	✓
A. bipartita cv. Bunderra	NSW Ag	✓					✓			✓
A. fulva (Lig179)	LIGULE		✓		✓				✓	✓
A. fulva (Dlf1)	NSW Ag				✓	✓				
A. pilosa (Dp1)	NSW Ag			✓						
A. duttoniana	NSW Ag			✓						
A. caespitosa (Dc1)	NSW Ag								✓	
M. stipoides cv. Wakefield	UNE		✓		✓				✓	✓
M. stipoides cv. Shannon	UNE		✓		✓				✓	
M. stipoides (Lig183)	LIGULE				✓					
M. stipoides (2402)	TIAR				✓					
M. stipoides (Ms1)	NSW Ag									✓
E. scaber (Lig473)	LIGULE	✓	✓		✓	✓		✓		
E. scaber (2405)	TIAR					✓			✓	
T. australis (Lig165)	LIGULE	✓	✓	✓			✓			✓
D. sericeum	NSW Ag						✓			

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