RGS

Aust. Rangel. J., 1976, 1,31-9

EMERGENCE, SEEDLING DEVELOPMENT AND SURVIVAL OF NATIVE AND EXOTIC GRASSES ON A SANDY RED EARTH IN SOUTH-WESTERN QUEENSLAND

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Abstract

The growth and development of eight perennial grasses, from sowing until flowering, was studied in the field on a sandy red earth near Charleville, south-western Queensland. They included four species native to this soil, *Thyridolepis mitchelliana, Aristida armata, Digitaria ammophila* and *Monachather paradoxa,* and four exotic species *Cenchrus ciliaris* cv. Biloela, *Anthephora pubescens, Eragrostis curvula* and *Schmidtia bulbosa.*

Cenchrus ciliaris, A. pubescens and *S. bulbosa* emerged much more promptly than the other species and much less viable seed was left in the soil after the first germination event. The native species tillered and flowered earlier than the exotic grasses and survived better under adverse growing conditions. Average survival at the end of the first growing season, during which good seasonal conditions prevailed, was 30% of the emergent seedlings. *Schmidtia bulbosa* performed best within the exotic group and this was associated with early tillering and earlier flowering.

The exotic species needed at least a four month growing season before they flowered under field conditions compared with two months or less for the native grasses. However this disadvantage was offset somewhat by their greater dry matter yield at this stage of development.

Introduction

The potential increases in productivity from exotic grasses in south-western Queensland were recognised by Ebersohn (1970). The species showing most promise was buffel grass (*Cenchrus ciliaris* L.). However, there are several major soil types where buffel grass does not thrive, in particular the mulga soils which are infertile, sandy loams to clay loams with limited water holding capacity (Dawson and Ahern 1973). Yet there is considerable interest by landholders in finding a suitable grass to sow following the clearing of mulga (*Acacia aneura*) scrub. Climatically this seems feasible, as mean annual rainfalls of up to 500 mm occur in the east of the region. Thus a programme to evaluate exotic plants has been conducted for the past eight years based at Charleville. A large number of species in the initial stages of the programme came from Africa and South America (Ebersohn 1969). Subsequently, numerous other lines, particularly of *C. ciliaris*, have been tested.

O'Donnell, *et al.* (1973) and O'Donnell and Smith (1975) have reported on the performance of the most promising introductions and species such as *C. ciliaris, Anthephora pubescens, Schmidtia bulbosa* and *Eragrostis curvula* have continued to persist and produce good yields under weed-free nursery conditions. However difficulties have been encountered in establishing these plants under field conditions, particularly on mulga soils.

The experiment reported here aimed to compare the field establishment and speed of development up to first flowering of a selection of useful native and exotic grasses in small plots on a type of sandy red earth which is widely distributed in the region.

Methods

The trial was conducted at Charleville, Queensland (26° 25'S; 146° 13'E) in a fenced two hectare clearing within a mulga scrub. A small, level area, four metres square was chipped clear of grass, thoroughly cultivated to a depth of 10 cm then raked smooth. A wooden frame was set in place to define the experimental area which consisted of a 9 x 4 randomised block. Each plot, sown to a single species, was 30 cm square and a 30 cm border separated each block.

The perennial grasses sown were:

(A) Native	(B) Exotic
Thyridolepis mitchelliana (Nees) S.T. Blake (mulga mitchell)	*Cenchrus ciliaris* L. cv. Biloela (buffel grass)
Aristida armata Henr. (wire grass)	*Anthephora pubescens* (Nees) CPI* 43713 (wool grass)
Digitaria ammophila (F. Muell.) Hughes (silky umbrella grass)	*Eragrostis curvula* (Schrad.) Nees CPI 33944 (South African lovegrass - Robusta green type)
Monachather paradoxa Steud. (mulga oats)	*Schmidtia bulbosa* Stapf. CPI 43715 (Kalahari couch)

An unsown plot in which the natural seed load of the soil was allowed to germinate was also included. On October 23, 1972, 200 seeds were sown in all other plots; caryopses were used where possible. Those not sown as caryopses were *Digitaria*, which still retained its lemma and palea, and *Aristida*, which only had its awns clipped. All seed was more than a year old at planting. The seed was scattered on the soil surface, scuffled in by hand, and the whole area, including borders, was then carefully watered with 75 mm of rainwater. Watering took 48 hours to complete and the soil was wetted to an average depth of 60 cm. At no stage during watering did the surface soil dry out.

At planting, samples of the seeds were tested for germination in the laboratory. Seed (3 replicates of 50) was placed on moist Ekwip pads in petri dishes and kept for 21 days in a germinator at $35^{o}/15^{o}C$ with 12 hours fluorescent light per day. These conditions approximated those in the field at the time. Seeds germinating in the laboratory (indicated by radicle extrusion) and seedlings emerging in the field (indicated by coleoptile emergence) were counted regularly.

In the field, emergent seedlings were counted daily for 8 days by which time some deaths had occurred. Subsequently overcrowded seedlings were thinned with a scalpel to manageable numbers and the seedlings removed were used to determine leaf number/dry matter yield relationships. Data were subsequently collected on the rate of growth, survival, first appearance of tillers and time of first flowering of the remaining plants. On exserting an inflorescence each plant was removed by cutting with a scalpel below its crown and its size recorded. The plots were exposed to natural field conditions, including heatwaves and grasshoppers for a whole growing season and observations were terminated in June 1973.

Heavy rain in late November 1972 produced further germination of most species, so seedlings emerging after this rain were also recorded and included in the results.

Statistical analyses could not be conducted on the seedling growth data because of the variation in population size between species and the intrusion of other variables which precluded the use of meaningful statistical procedures. However, transformed germination and emergence data were analysed by an analysis of variance and the means separated using Duncan's significant studentized ranges.

Results

Germination

Three of the exotic species showed rapid, high germination in the laboratory whilst *Eragrostis* and the native grasses germinated more slowly and had a significantly lower total germination (Table 1). Field emergence pattern (Fig. 1) was similar. Final emergence after the initial watering varied considerably between blocks but in general was correlated with speed of germination in the laboratory. On average, 30% of viable seed sown emerged although *Anthephora* was best with 49% (Table 1). Individual plots had emergence values ranging between 11 and 65%. In the unsown plots an average total of 15 seedlings emerged after the two germination events and of these 29% were not grasses. There were no consistent differences in emergence between the four blocks.

*CPI = Commonwealth Plant Introduction Number

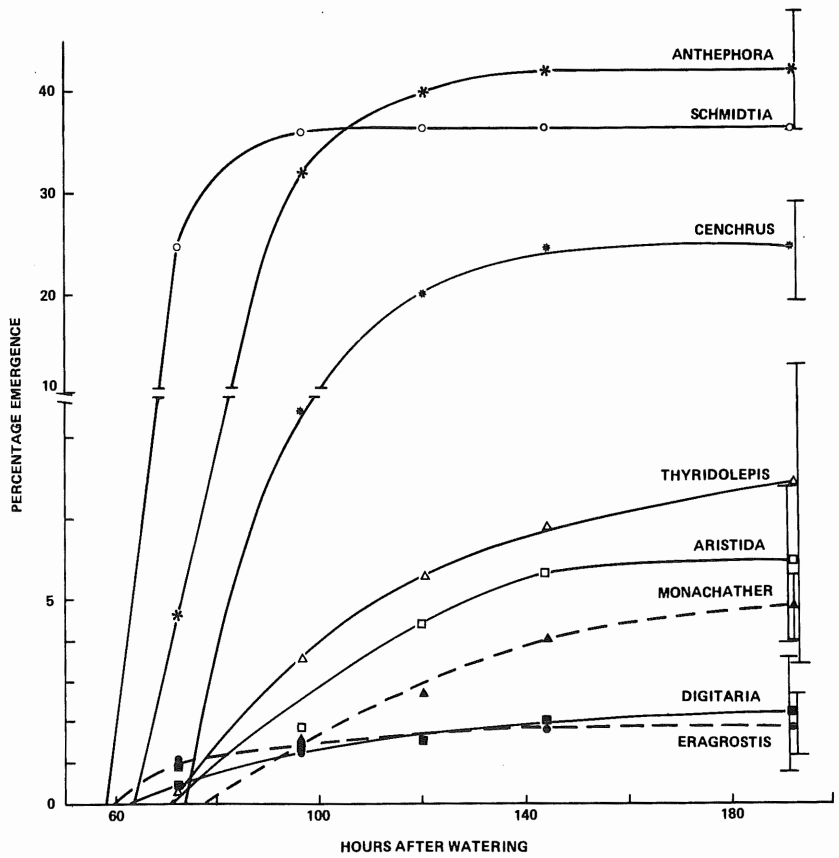

Fig. 1. Field emergence pattern of native and exotic grasses sown on a sandy red earth and artificially watered. Bars show the standard error of the final values.

Table 1. Field emergence of native and exotic grasses compared to laboratory germination

Species	Average laboratory germination (%)	Initial field emergence (%)	Residual emergence after 89 mm of November rain (%)	Total emergence as a percentage of laboratory germination
(A) Native				
Thyridolepis	54bc*	9.0b	5.0ab	28
Aristida	28d	6.8b	2.8b	34
Digitaria	45c	3.3b	6.5b	22
Monachather	31cd	5.4b	2.0bc	24
(B) Exotic				
Cenchrus	88a	27 a	0.7bc	31
Anthephora	70b	33 a	0.7bc	31
Eragrostis	55bc	3.3b	5.1ab	15
Schmidtia	92a	32 a	0 c	35

* Figures followed by the same letters in any column do not differ significantly from one another ($P<0.05$)

Apparently very few seeds of the exotic species remained to germinate after the initial watering. However, as many seedlings of the native species emerged after the late November rain as from the initial watering. Of the exotics only *Eragrostis* had many seedlings emerging after the November rain. Emergence after the November rain was inversely correlated (r = 0.93***) with the initial field emergence (Fig. 2).

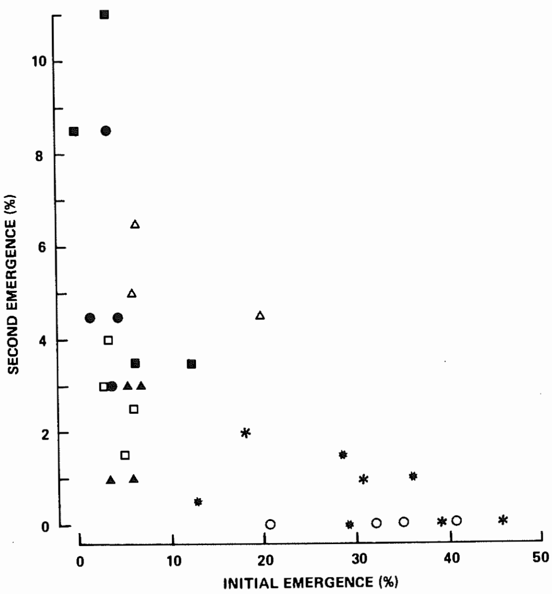

Fig. 2. Relationship between initial and residual emergence of sown grasses. Symbols correspond to those in Fig. 1.

Weather conditions

For the first month after planting, conditions were mild and dry but good rains were received in late November and early December. A severe heatwave lasting for 16 days in late December/early January caused many seedling mortalities but storm rains brought relief in the second half of January (Fig. 3). Then followed an exceptionally wet month in February (290 mm), a dry, mild March/early April period and some good falls of rain late in April.

A total of 420 mm of rain fell during the seven month trial period, which is above the Charleville average (380 mm). No frosts were experienced during the trial.

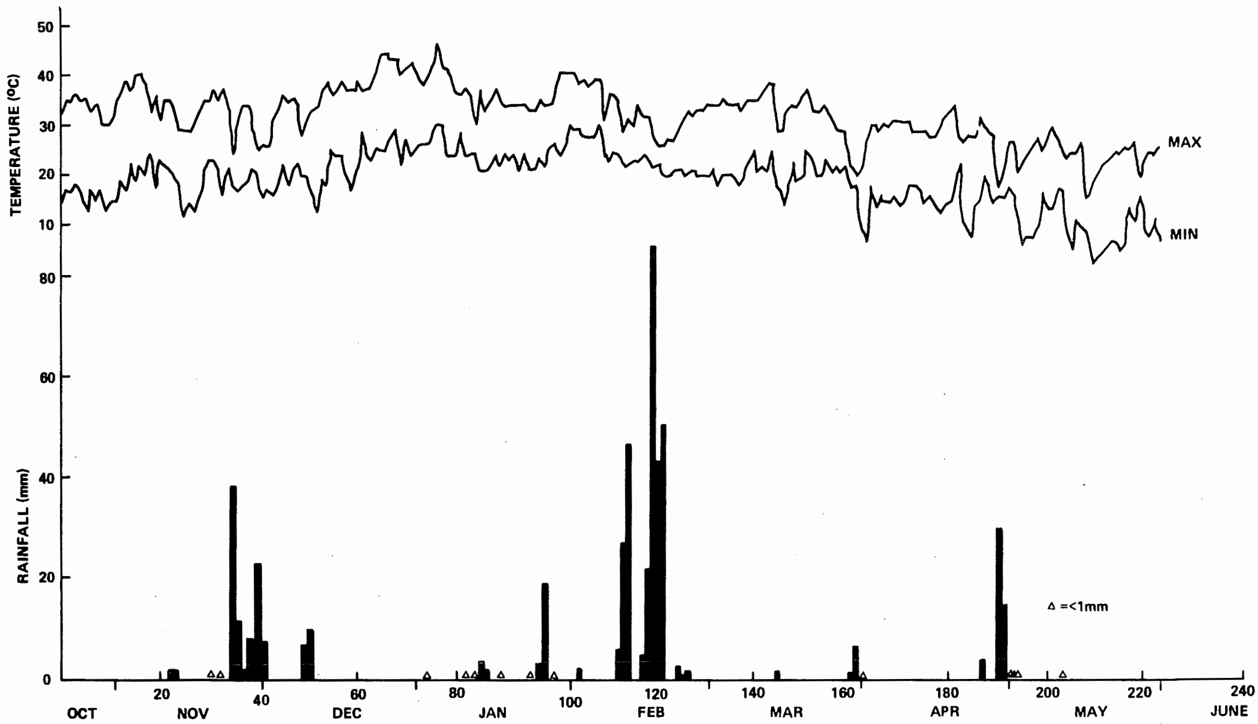

Fig. 3. Rainfall and temperature extremes experienced at Charleville during the experiment (October 1972 to June 1973).

Seedling growth

Though seedling growth rate was only monitored on the fastest growing plant in each plot, it became obvious within two weeks of sowing that all plants in a large section of the trial were growing at a slower rate than the others. All species were affected and it was discovered that a previously undetected termite nest existed beneath this section causing a marked increase in soil strength and bulk density to a depth of 45 cm. Chemical analyses of the soil showed that this was probably not a direct nutritional effect. Where the old nest only influenced part of a plot the effect was seen in either slower tillering or flowering, or poorer seedling survival or both, depending on the species (Table 2 and 3). All block 2 and parts of block 1 and 3 were affected with the different species suffering to varying degrees.

Thus data on seedling growth are presented for plants growing in both favourable (block 4) and unfavourable (block 2) areas. In general the exotic species produced leaves at a slower rate than the natives (Fig. 4) and rarely grew as vigorously as the natives in either situation. *Schmidtia* was the only exotic able to match the rate of leaf production of the natives, under good conditions. Even under adverse conditions some *Aristida* and *Thyridolepis* plants eventually established a satisfactory rate of leaf production before the December/January heatwave began about 60 days after sowing.

Table 2. Development rate and flowering success of native grass seedlings growing on an infertile sandy red earth

		Percentage of emerging seedlings which flowered		Largest plant data			
				Days to tiller		Days to flower	
Species	Block	A	B	A	B	A	B
Thyridolepis	1*	17	50	26	18	43	62
	2**	11	50	43	n.d.	103	100
	3	54	11	17	n.d.	43	74
	4	57	20	17	18	40	69
Aristida	1**	14	14	43	112	85	137
	2**	67	0	40	–	68	–
	3	100	78	17	18	40	56
	4	100	60	17	18	40	56
Digitaria	1	–	0	–	42	–	–
	2**	0	0	–	–	–	–
	3*	100	0	26	–	50	–
	4	86	0	17	–	43	–
Monachather	1*	77	50	26	n.d.	43	151
	2**	0	83	–	85	–	100
	3**	20	0	26	–	85	–
	4	67	0	26	–	43	–

Column A = initial seedling emergence
Column B = emergence after November rain
n.d. = no data collected

** Plot completely affected by old termite nest
* Plot partially affected by old termite nest
– no plants survived to this stage

Up until 50 days of age no obvious wilting of seedlings occurred. During this period measurements on thinned seedlings showed there was a close linear relationship between leaf number and the dry matter yield of plants within a species. Thus the average yield of the natives by December 13, 1972 was higher than for the exotics, though some *Schmidtia* plants were as big. Some of the native grasses had flowered within this time.

Tillering, flowering and survival

Most native species first tillered when 17-26 days old though this increased to 40-43 days under poor soil conditions.

By comparison the exotic grasses, other than *Schmidtia*, took 27-48 days under good conditions and 140-190 days under poor conditions, if they survived that long. Good conditions allowed the most advanced natives to exsert an inflorescence when only 40-43 days old with the average age at flowering being 50 days, while *Schmidtia* first flowered at 64 days of age. However, for those *Schmidtia* plants which flowered the average age at flowering was 117 days, while *Cenchrus* always took over 138 days and most plants of the other two exotic species had not flowered after 215 days. The trial then terminated. *Aristida,* with an average age at flowering of 46 days, was slightly faster than the other native species. All surviving native seedlings flowered before winter while many exotic ones did not, particularly *Anthephora* which did not flower until the following spring. Under poor soil conditions no exotics flowered in the first growing season.

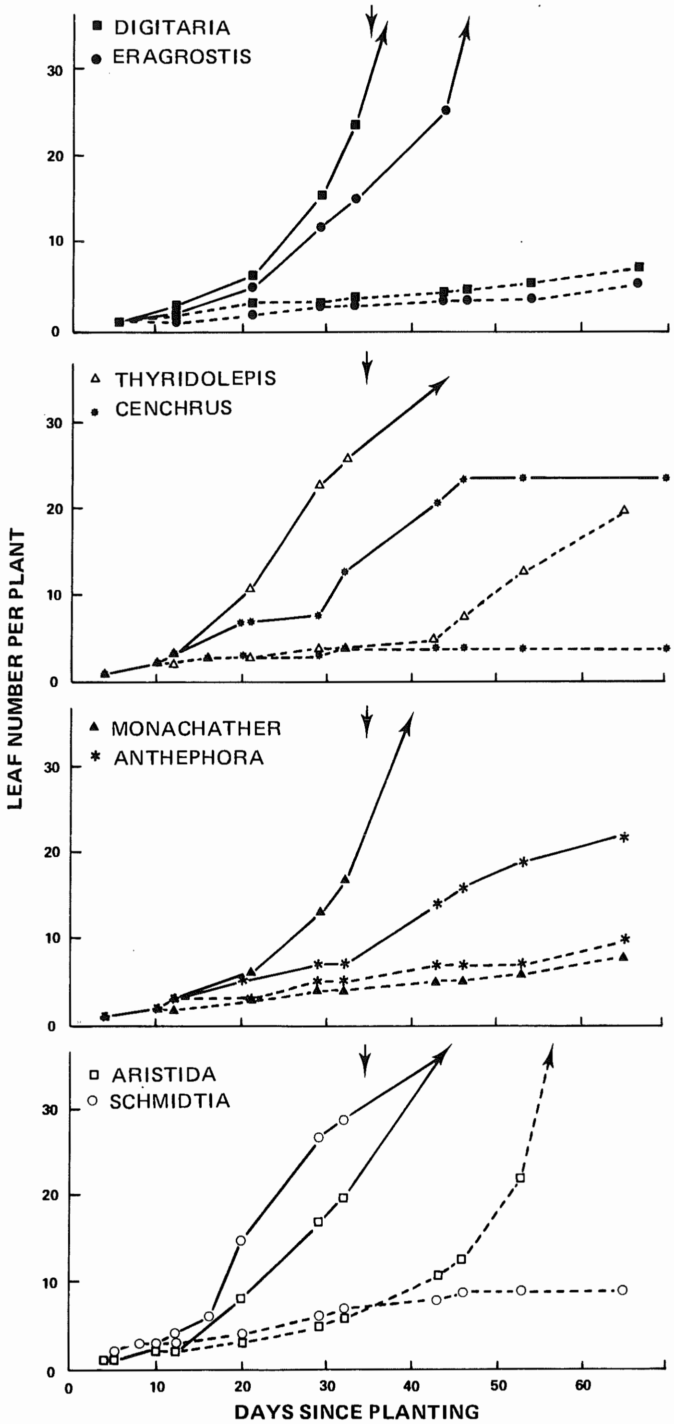

Fig. 4. Rate of leaf production by native and exotic grasses on an infertile sandy red earth under 'good' (——) and 'poor' (– – –) soil physical conditions. The arrows indicate when rain began falling in November.

Table 3. Development rate and flowering success of exotic grass seedlings growing on an infertile sandy red earth

Species	Block	Seedling (%) Death	Flowered	Still vegetative (June 12, 1973)	Largest plant data Days to tiller	Days to flower
Cenchrus	1*	88	2	10	48	160
	2**	100	0	0	–	–
	3	43	12	45	30	142
	4	78	11	11	30	138
Anthephora	1**	98	0	2	173	>215
	2**	90	0	10	187	>215
	3	69	0	31	41	>215
	4	68	0	32	41	>215
Eragrostis	1**	100	0	0	–	–
	2**	100	0	0	–	–
	3	71	6	23	27	111
	4	89	0	11	27	>215
Schmidtia	1*	46	13	41	18	64
	2**	92	0	8	142	215
	3*	21	46	33	27	89
	4	27	60	13	18	64

** Plot completely affected by old termite nest
* Plot partially affected by old termite nest
– no plants survived to this stage

The average dry matter yield of the tops of the exotic species at flowering was much greater than that for the native species: *Cenchrus* 6.05 g, *Eragrostis* 6.04 g and *Schmidtia* 3.6 g compared to *Digitaria* 1.12 g, *Monachather* 0.65 g, *Aristida* 0.5 g and *Thyridolepis* 0.45 g. *Schmidtia* was again the exotic which performed most like the natives.

Most seedling deaths occurred during the December/January heatwave and no seedling deaths were recorded after January. No exotic seedlings emerging after the November rain survived even to the tillering stage, whereas a significant number of natives did. The growth and survival of *Digitaria* was poorer than most other species, especially the other natives. Overall 28% of emergent seedlings from both groups survived to the end of the first growing season i.e. 9% of the laboratory germinable seed.

Discussion

Field emergence of sown seed was strongly influenced by the germinability of the seed and speed of laboratory germination. Matching of field and laboratory temperature extremes plus the use of caryopses to remove seedcoat constraints to germination undoubtedly influenced this association. However, the variable emergence of individual species among blocks is difficult to explain. During preparation of the site every effort was made to produce an even seedbed. Ants were very active in block 1 despite attempts to control them with insecticides. They showed a preference for *Thyridolepis* grain which may have contributed to the lower emergence figure for this species in that block.

Variable emergence was unaffected by any seed initially in the soil before sowing as only a small proportion of the plants removed during thinning came from unsown seed. Only *Digitaria* seedlings could not have their origin checked because unlike the others, seed of this species was sown in its natural condition. The density of native seedlings emerging from unsown seed was in the range reported for the area after good falls of rain (Silcock 1973) but no exotic grasses from nearby nursery sites emerged in these unsown plots.

Where seed was sown in its normal state, e.g. *Eragrostis, Aristida* and *Digitaria* residual germination was greater (Fig. 2). This was thought to be partly because seedcoats reduced seed spoilage (in the case of *Aristida* and *Digitaria*) and partly due to the normal degree of dormancy which many of the native species exhibit, most likely as a survival mechanism suited to the harsh environment in which they grow. *Monachather* exhibited an unusually low level of residual germination which could be a result of its susceptibility to pathogenic attack when removed from its seed coats (Silcock - unpublished data).

An average field emergence of 30% from the germinable seed sown compares favourably with other Australian data (Lazenby and Schiller 1969; Jones and Rees 1973), especially as there was no humid atmosphere prevailing after the initial watering, as would normally be the case after 75 mm of rain. Only *Eragrostis* showed a consistently low germination, which is unusual for this species (Silcock - unpublished data).

The reason for the poor seedling growth in the section affected by the termite nest is not clear but has been examined in more detail elsewhere (Silcock 1975). It was surprising that early shoot growth was affected so severely while good moisture conditions prevailed, especially as the surface soil had been well cultivated before planting. Establishment of some plants above the nest was feasible as grass was cleared from all parts of the trial area prior to the experiment.

A greater tolerance of heat and moisture stress under adverse conditions appeared to be a major difference between the native and exotic species; when conditions were good all grew well, but when growing conditions were poor the natives often survived and flowered while the exotics failed, e.g. *Thyridolepis* and *Aristida* in block 2. The exception in the native species was *Digitaria* which showed an inability to withstand moisture stress as a seedling. This has been noted before (Silcock 1975). Under good conditions *Schmidtia* exserted leaves at a slightly faster rate than even the very competitive *Aristida,* confirming its reputation as the best coloniser of the exotic species used (O'Donnell *et al.* 1973). Because of its larger leaves *Schmidtia* probably also had a greater dry matter yield than other species in the first 7 weeks under good conditions.

Compared to the average age at tillering of 57 days for the perennial grasses reported by Silcock (unpublished) the seedlings in this trial tillered early. However, in view of the excellent conditions prevailing during early establishment in this trial, the earlier tillering is understandable. Note that in the poor areas *Monachather, Digitaria, Cenchrus* and *Eragrostis* failed to reach the tillering stage. Early tillering usually led to the development of a nodal root system earlier and thus should have increased the stress tolerance of plants after that time.

Flowering success varied with the species and the growing conditions in a similar manner to tillering. The exotic species failed to flower during the trial except under good growing conditions. Under poor conditions the surviving native species, though taking 80-100 days to reach flowering, did eventually achieve this stage. Again the favourable seasonal conditions resulted in a shorter average time to flowering for the native grasses than the 193 days reported by Silcock (1975) for more normal seasonal conditions.

Other field data available on the exotics indicates that under less competitive nursery conditions these species may flower in a shorter time than in this experiment (Smith – unpublished data). From seed sown on December 27, 1969, *S. bulbosa* first flowered in 82 days, *C. ciliaris* in 94 days and *E. curvula* in 113 days. *Anthephora pubescens* had an occasional plant flowering after 116 days but few flowered before winter as in this trial.

In view of the exceptionally good seasonal conditions experienced during this trial, the comparatively late flowering of the exotic species may be viewed with apprehension. Any perennial grass seedling in this semi-arid environment needing greater than a four month growing season to reach flowering will require very careful management in the seedling year (or until it flowers), if it is to be successfully introduced.

Unless the sown seed is quickly replenished in the ground the species will always be vulnerable to elimination (Silcock and Whalley 1974), especially where grazing by marsupials is difficult to control. Nevertheless considerable variability in earliness of flowering exists within the *C. ciliaris* lines under trial at present, so scope exists for reducing the time of flowering in this species at least. However, while this trial studied earliness of flowering, no assessment was taken of seed set which is the really important criterion. If the first flowering of the native species largely failed to produce seed then their earliness may not be as important as is presently supposed. Data are still required on this point.

Acknowledgements

Financial support for this project was provided by the Wool Research Trust Fund and is gratefully acknowledged.

References

Dawson, N.M. and Ahern, C.R. (1973) Soils and landscapes of mulga lands with special reference to south western Queensland. *Trop. Grasslds* 7, 23-34.

Ebersohn, J.P. (1969) A reconnaissance plant collection in Peru, Brazil, Ethiopia and Rhodesia for semi-arid Queensland. *CSIRO Pl. Introd. Rev.* **6**, 15-9.

Ebersohn, J.P. (1970) Herbage production from native grasses and sown pastures in south-west Queensland. *Trop. Grasslds* **4**, 37-41.

Jones, R.M. and Rees, M.C. (1973) Farmer assessment of pasture establishment reliability in the Gympie district, south-east Queensland. *Trop. Grasslds* 7, 219-22.

Lazenby, A. and Schiller, J.M.A. (1969) Emergence and early seedling growth of *Phalaris tuberosa. Aust. J. Exp. Agric. Anim. Husb.* **9**, 422-7.

O'Donnell, J.F. and Smith, Flora T. (1975) Evaluation of a plant collection from South America and Africa. *CSIRO Pl. Introd. Rev.* **10(2)**, 21-31.

O'Donnell, J.F., O'Farrell, R. and Hyde, K.W. (1973) Plant introduction and reseeding in the mulga zone. *Trop. Grasslds* 7, 105-10.

Silcock, R.G. (1973) Germination responses of native plant seeds to rainfall in south-west Queensland. *Trop. Grasslds* 7, 99-104.

Silcock, R.G. (1975) Factors influencing the establishment of perennial grasses on the lateritic red earths (mulga soils) of south-western Queensland. M.Sc. Thesis, University of New England, Armidale.

Silcock, R.G. and Whalley, R.D.B. (1974) Factors contributing to the success of Australian grasses over higher yielding exotic grasses from similar semi-arid homoclimates. *Proc. XII Internat. Grassld Congr.*, Moscow, 1974, pp. 322-9.