PERFORMANCE OF WARM-SEASON PERENNIAL GRASSES FOR IRRIGATED PASTURES AT DENILIQUIN, SOUTH-EASTERN AUSTRALIA

V. R. SQUIRES* AND L. F. MYERS†

ABSTRACT

Seasonal production of Cenchrus ciliaris, Eragrostis curvula, Panicum coloratum, Paspalum dilatatum, Sorghum almum, *and* Phalaris tuberosa x Phalaris arundinacea *was measured over three years and two levels of nitrogen under flood irrigation at Deniliquin, N.S.W.*

Yields of all species were increased ($P < 0.05$) by intermittent 24 hour inundation. E. curvula *and* P. coloratum *gave the highest annual yields. Autumn production from* P. coloratum *and spring production from* E. curvula *were higher than from other grasses.* C. ciliaris, *though productive in the first year, did not survive the winter.*

Preliminary evaluation under grazing suggested that no grass was superior to P. dilatatum, *in terms of liveweight gain by sheep, when sown with* Trifolium repens *and set stocked at high rates over summer.*

INTRODUCTION

The standard warm-season species for irrigated perennial pastures in the southern inland irrigation districts are *Paspalum dilatatum, Lolium perenne* and *Trifolium repens.* The seasonal productivity of these species was assessed in pure swards under irrigation at Deniliquin, N.S.W. by Davidson (1964).

Dann (1965) reported the performance of several perennial species in terms of persistence and productivity when in irrigated swards and managed under farm conditions at Yanco, N.S.W. Warm-season perennial grasses such as *Sorghum almum, Panicum coloratum, Cenchrus ciliaris* and *Eragrostis curvula* have yet to be assessed in this cool winter environment.

Six perennial grasses with greatest productivity during warm months and with known resistance to frost were tested for yield and seasonal production. Initially the grasses were tested under a cutting regime in pure swards either with or without nitrogen fertilizer. Subsequently four species, selected on the basis of highest seasonal productivity, were grown with an associated legume and grazed at two levels of stocking.

The relative merits of the grasses are presented here, as assessed by the two testing procedures, under flood irrigation at Deniliquin, N.S.W. The influence of irrigation-management and nitrogen fertilizer on the yield, persistence and seasonal productivity is also reported.

ENVIRONMENT

Deniliquin (35° 30'S latitude) receives a mean annual rainfall of 15.9 inches (95 year average) and evaporation from an Australian standard tank, exceeds 60 inches per annum. Irrigation is essential for reliable growth of crops and pastures and approximately 40-45 acre inches are required to supplement rainfall. Temperatures are high during summer with an average of 11 days exceeding 100°F and 63 days exceeding 90°F. In 1961 there were 8 severe frosts (screen temperature below 32°F)

* C.S.I.R.O. Division of Plant Industry, Riverina Laboratory, Deniliquin, N.S.W. 2710.
† Present address: C.S.I.R.O. Division of Plant Industry, Canberra A.C.T. 2601.

and 13 light frosts (screen temperature 33-36°F) while in 1962 there were 11 severe frosts and 15 light frosts. The mean monthly minimum and maximum temperatures and rainfall distribution are shown in Fig. 1.

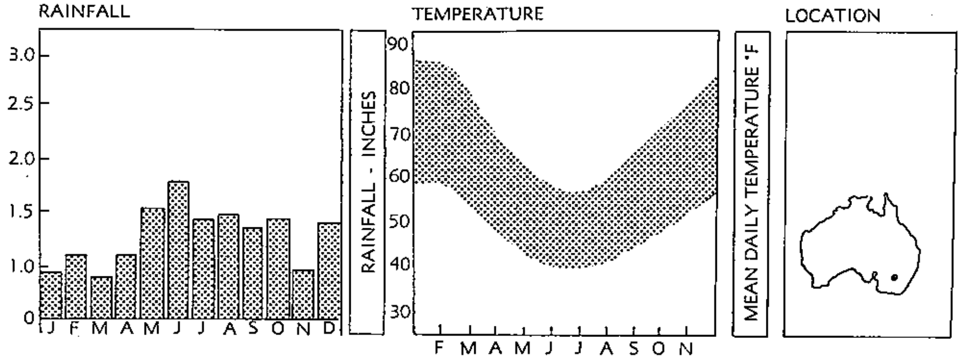

FIGURE 1
Average climatic data for Deniliquin (35-30°S, 144-30°E) (Av. 95 years).

The soil, Billabong Clay (Smith 1945), is characterized by a shallow loam surface overlying a medium to heavy clay. Mean slope is about 0.05 per cent.

MATERIALS AND METHODS

Cutting trial

Species

Paspalum dilatatum, Sorghum almum, Cenchrus ciliaris cv. Biloela, *Panicum coloratum* CPI* 13372, *Eragrostis curvula* CPI 1666 and CPI 14369, were sown in a randomized block with eight replicates in 33 x 6 feet plots on October 10, 1960 at a sowing rate of 12 viable seeds/ft.[2] *Phalaris tuberosa* x *Phalaris arundinacea* was planted vegetatively at eight in. spacings. *P. coloratum* did not emerge satisfactorily and was replanted vegetatively at 24 in. spacings in spring 1961.

Fertilizer

Gypsum (4840 lb/acre) and superphosphate (448 lb/acre) were applied to the surface before sowing or planting. The equivalent of 50 lb of N per acre was applied (as $(NH_4)_2SO_4$) at six weekly intervals to half of each plot, initially selected at random. The total annual dressing was 425 lb N/acre. The other half received no nitrogen fertilizer.

Irrigation

The plots were irrigated on an approximate two inch evaporation interval during spring, summer and autumn. Irrigation was suspended from May to August. In the second summer (1961-2) a 24 hour "flooding" treatment was imposed on four replicates. The duration of the flooding on these four replicates was extended to 48 hours in the summer of 1962-3. The other four replicates were inundated for three to four hours only (i.e. irrigated normally) in both summers.

Measurements

Harvesting began on January 17 1961, twelve weeks after sowing. Subsequent harvests were at six week intervals during the growing season. Because of poor

* Commonwealth Plant Introduction.

growth an interval of 12 weeks was necessary between harvests in winter. Yields were determined by cutting 10 per cent of the area of each sub-plot to ground level. After oven drying for 16 hours at 180°F, samples were analysed for nitrogen by the Kjeldahl method.

Basal cover of each species was determined after a severe defoliation at the commencement of the 48 hour flooding treatment in December 1962 and again in April 1963 using a point quadrat having 10 points four inches apart. One hundred random quadrats (1000 points) were taken in each sub-plot.

General management

Immediately after each sampling the area was grazed to ground level with a large flock of sheep (c.300/acre) and was then left ungrazed until the next sampling. Plots were kept weed free by hand hoeing.

Preliminary evaluation under grazing

The assessment of forage grasses must be made under conditions relevant to the pastures use on the farm viz: as a supplement to the standard winter pasture based on subterranean clover (*T. subterraneum*) and annual rye grass (*L. rigidum*) or *P. tuberosa.* For this purpose a high stocking rate in summer (November 15th to March 15th) is necessary and as high a stocking rate as possible is desirable during the rest of the year (Myers 1967).

Four of the six grasses tested in mown swards were sown in association with *T. repens* (cv. Ladino). The species were *E. curvula, P. dilatatum, P. coloratum* and *P. tuberosa* x *P. arundinacea.*

An area was laid out for flood irrigation and sown in May 1962 to subterranean clover. After senescence, in November 1962, duplicate 0·25 acre plots were oversown with each of the four grasses along with 4 lb/acre of white clover. The pasture was maintained by periodic mowing until August 1963 when grazing by Merino wether hoggets (mean weight 71.6 lb) commenced.

The plots were stocked at high levels in summer (November-March) and at low levels in winter and spring (April-October). The stocking rate sequences adopted were

HEAVY STOCKING	32 sheep per acre		Summer
	8 ,, ,, ,,		Winter/Spring
LIGHT STOCKING	24 sheep per acre		Summer
	8 ,, ,, ,,		Winter/Spring

Bodyweight change over summer was used as the only criterion in this assessment.

RESULTS AND DISCUSSION

Cutting Trial

Seasonal production

Seasonal and total production of dry matter in the first year (1961-2) are shown in Table 1. *Phalaris* hybrid, originally established from vegetative material, gave the most consistent yield. However it was outyielded by all other species in summer and by *C. ciliaris* in autumn.

Dry matter yields for each grass at both nitrogen levels are presented for the season 1962-3 in Table 2. *E. curvula* on nitrogen treated plots was superior in spring ($P < 0.05$) to the other grasses and had a higher total yield. In the absence of applied nitrogen, yields of *P. coloratum* were considerably greater than those of

TABLE 1

Seasonal production of first year irrigated grasses
All yields as dry matter based on 6 weeks regrowth
Means of 2 cuts*

Species	Level of N. fertilizers† lb N/acre	Summer‡	Autumn	Winter	Spring	Annual** Total
		lb/acre	lb/acre	lb/acre	lb/acre	lb/acre
Paspalum dilatatum	425	934	630	—	362	5734
	0	745	118	—	39	2428
Sorghum almum	425	2698	837	—	—	12558
	0	1969	489	—	—	7274
Cenchrus ciliaris	425	2360	1105	—	—	7705
	0	1760	743	—	—	5825
Panicum coloratum	425	—	225	—	3288	3513
	0	—	81	—	2407	2488
Eragrostis curvula	425	1985	633	—	1528	13157
	0	1561	405	—	641	7282
Phalaris hybrid	425	847	1023	1605	1584	12368
	0	721	448	793	977	7445

**From 10-1-61 to 24-1-62.
*Yield obtained from 4 replicates only.
†High = 425 lb/N/acre/year as 50 lb N/acre dressings applied after each harvest.
Low = No added N fertilizer.
‡Excludes yield from first harvest 12 weeks after sowing on 10-10-60.

other grasses. Growth rates of *P. coloratum* in autumn exceeded 100 lb DM/acre/day, double that from *P. dilatatum*. *Phalaris* hybrid outyielded *P. dilatatum* in every season except summer, and was the only grass to produce harvestable amounts in six weeks during winter (Table 2).

TABLE 3

The interaction between intermittent summer flooding and performance of six warm-season grasses in flood irrigated swards
Yield (lb DM/acre)

Irrigation	Normal	Flooded 24 hrs*	Normal	Flooded 24 hrs	Normal	Flooded 48 hrs†
Level of N	Nil		425 lb/acre		Nil	
Species						
Cenchrus ciliaris	230	1479	2996	5203	—	—
Sorghum almum	456	1153	2992	3514	1130	2040
Phalaris hybrid	330	937	1978	2646	640	727
Paspalum dilatatum	94	489	1247	3161	262	2285
Eragrostis curvula	575	1120	3301	3954	1149	2304
Panicum coloratum	1761	2284	4292	4762	1982	3210
L.S.D. ‡P = 0.05	665		837		859	
P = 0.01	903		1158		1212	

*24 hour flooding at each irrigation from January 1962-May 1962.
†48 hour flooding at each irrigation from January 1962-May 1963.
‡Between flooded and normal irrigation.

TABLE 2

Effect of nitrogen fertilizer on seasonal production of six warm-season perennial grass in flood irrigated swards
Yield (lb dry matter/acre) based on 6 weeks regrowth
Data pooled for flooding treatment

Species	Level of N lb N/acre	Summer 1962		Autumn 1962*		Winter 1962‡		Spring 1962*		Summer 1963*		Autumn 1963		Annual total†	
		425	0	425	0	425	0	425	0	425	0	425	0	425	0
Paspalum dilatatum		1340	292	2204	529	—	—	856	109	2642	1274	852	380	6052	1558
Sorghum almum		2608	804	3523	1148	264	58	723	187	3867	1585	1142	376	8606	2980
Cenchrus ciliaris		1717	854	4100	2190	466	152	—	—	—	—	—	—	6229	3246
Panicum coloratum		2637	2023	4527	3114	472	269	662	348	4867	2956	2288	1021	10416	6724
Eragrostis curvula		1984	847	3628	1238	837	178	2832	868	4229	1727	1415	647	11490	3824
Phalaris tuberosa x *arundinacea*		1072	634	2312	1008	1864	297	2372	733	1728	684	411	154	8753	3032
L.S.D. P = 0.05		707	468	544	419	429	138	451	236	1067	509	473	284		
P = 0.01		952	631	733	564	582	187	612	321	1446	690	641	385		

*Yield is mean of 2 cuts.
†From 24-1-62 to 7-1-63.
‡12 weeks between harvests.

Effects of flooding

Yields of all species were significantly increased ($P < 0.05$) as a result of flooding for 24 hours at each irrigation during summer and autumn 1962. There was a significant interaction ($P < 0.01$) between species and flooding with intermittent 48 hour inundations during summer 1963 for low nitrogen plots (Table 3). The yields of all grasses except *Phalaris* hybrid were significantly increased by 48 hour flooding. *C. ciliaris* was reduced to low densities during winter 1962 and was omitted from the analyses.

The beneficial effects of intermittent 24 hour flooding during summer-autumn 1961-2 were probably due to additional storage of water in the soil (Loveday 1964). Yields were higher on flooded plots which received no nitrogen fertilizer than on similar plots irrigated normally. This was probably due to improved water storage which permitted growth further into the drying cycle.

Effects of nitrogen fertilizer

Addition of nitrogen fertilizer increased yield (Table 2); furthermore the response to nitrogen was greater on plots irrigated normally than on flooded plots regardless of species.

There was a smaller response to added nitrogen in *P. coloratum* than in other grasses (interaction significant ($P < 0.05$)). There were marked seasonal changes

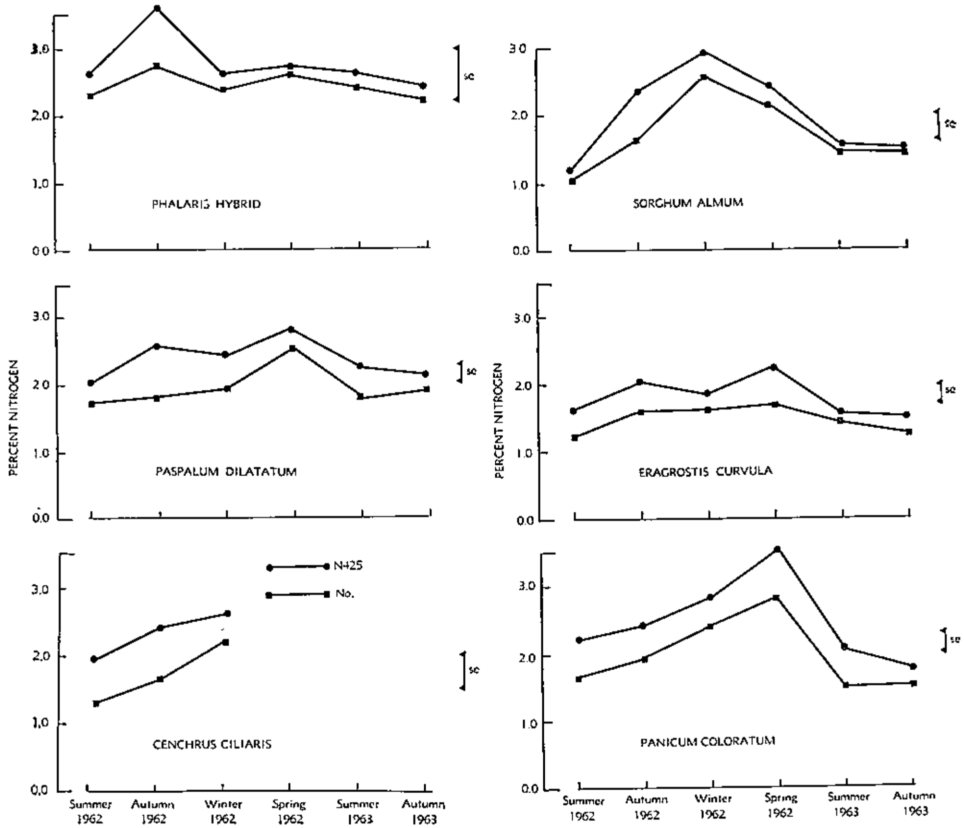

FIGURE 2

Seasonal changes in percent nitrogen in six warm-season grasses as influenced by level of nitrogen fertilizer.

in nitrogen content of the forage at both levels of nitrogen fertilizer (Fig. 2). Nitrogen percentage sometimes fell below 1.5 percent, e.g. *E. curvula* and *S. almum* on low nitrogen plots. Intermittent flooding did not change nitrogen content.

Persistence under flooding

Since there were differences between species in growth habit, persistence under flooding was measured by increase in bare ground as gauged by point quadrats. There were significant differences in cover between species at both samplings (Table 4). In December 1962 there was more bare ground on low nitrogen plots than on high nitrogen plots ($P < 0.01$). However by April 1963 this difference was eliminated.

TABLE 4

*Effect of periodic 48 hour flooding during summer on basal cover of warm-season perennial grasses**

Species	Bare ground†	
	December 1962	April 1963
Paspalum dilatatum	494	573
Sorghum almum	919	913
Panicum coloratum	848	814
Eragrostis curvula	638	643
Phalaris hybrid	641	784
Cenchrus ciliaris	969	‡
L.S.D. P = 0.05	55	111
P = 0.01	77	155

*Both high and low nitrogen plots analysed together.
48 hour flooding at each irrigation from January 1963-April 1963.
†Number of strikes of bare ground from 1000 points per sub-plot.
A low figure indicates a denser stand.
‡Complete removal—omitted from analysis.

There was no significant effect of nitrogen level on species density at the end of experiment. Persistence of *E. curvula, P. coloratum, Phalaris* hybrid and *P. dilatatum* under the cold, wet winter conditions was good in contrast to *C. ciliaris* which failed to recover fully after the second winter and *S. almum* which was severely reduced by frost damage.

Density of both *Phalaris* hybrid and *P. dilatatum* was reduced by intermittent 48 hour flooding during summer-autumn 1963.

Animal production

P. coloratum failed to establish at satisfactory densities and was omitted from the comparison. Bodyweights of all flocks were satisfactory in the winter phase.

Ranking of the grasses in terms of bodyweight change of sheep over the 130 days, November 5 to March 15, is shown in Table 5. *P. dilatatum* was best at the lower stocking rate while sheep on *E. curvula* at the higher rate lost less than those on other grasses.

This reversal of ranking as stocking pressure increased was probably due to the interaction of quality and quantity. *E. curvula* is a relatively unpalatable species (Arnold 1963), has a low crude protein level in all seasons (Fig. 2) and is less digestible than *P. dilatatum* (Robards and Wilson 1967). At low rates of stocking, liveweight gains on *E. curvula* were low in spite of an ample supply of forage. Low quality of pasture would reduce intakes and probably explains the higher yields of *E. curvula*. At high rates *E. curvula* was the only species to produce harvestable amounts.

TABLE 5

Ranking of grass species on basis of liveweight changes in sheep

Stocking Rate and Rank	Nett Liveweight Change*
	lb/sheep S.E.
24 sheep/acre*	
1. *Paspalum dilatatum*	+24.7 ± 1.7
2. *Eragrostis curvula*	+ 6.4 ± 1.6
3. *Phalaris* hybrid	+ 4.8 ± 1.5
32 sheep/acre*	
1. *Eragrostis curvula*	— 8.6 ± 1.5
2. *Paspalum dilatatum*	—15.2 ± 2.6
3. *Phalaris* hybrid	—19.8 ± 0.4

*130 days from November-March. For details see text.

CONCLUSIONS

Under cutting, a number of grasses was superior to *P. dilatatum,* particularly *E. curvula* which gave the highest total yield with added nitrogen (Table 2) and had a better growth rate than *P. dilatatum* in all seasons. However, crude protein levels in *E. curvula* were generally lower than those in other grasses (Fig. 2), especially in the absence of added nitrogen, although combination with a suitable legume may overcome this. *P. dilatatum* performed much better under grazing at 24 sheep/acre (Table 5). This was further supported in a "put and take" grazing experiment (Squires and Myers 1968).

P. coloratum, although it yielded well under cutting, was difficult to establish from seed, which may limit its wider use (see also Bryant 1967).

On present evidence it appears unlikely that any of the grasses evaluated in these experiments will supplant *P. dilatatum* as the principal grass in irrigated perennial pastures in south-east Australia.

ACKNOWLEDGEMENTS

The authors are grateful to Mr. R. J. Williams, Plant Introduction Officer, Brisbane, for advice on initial selection of species and to Dr. J. R. McWilliam, C.S.I.R.O., Canberra, for the F_1 hybrid material. Miss Sheila Green, Division of Mathematical Statistics, C.S.I.R.O., Canberra, was responsible for the statistical analyses.

The staff of the Falkiner Memorial Station gave valuable assistance in the field. The chemical analyses were performed by Messrs. R. H. Crockford and M. R. C. Holmes and Miss J. Shearer.

REFERENCES

ARNOLD, G. W. (1963)—The diet of the grazing sheep. Ph.D. Thesis. University of London.

BRYANT, W. G. (1967)—Interim assessment of introduced plants. 1. *Panicum coloratum* L.

C.S.I.R.O., Australia, Division of Plant Industry, Plant Introduction Review **3**(3): 18-33.

DANN, P. R. (1965)—Performance of six perennial grass swards under common grazing and spring-summer-autumn irrigation at Yanco, N.S.W. *C.S.I.R.O., Australia, Division of Plant Industry, Field Station Record.* **4**(2): 63-70.

DAVIDSON, J. L. (1964)—Species and strain production under irrigation at Deniliquin. Results from field trials 1958-60. *C.S.I.R.O., Australia, Division of Plant Industry, Field Station Record.* **3**(1): 1-12.

LOVEDAY, J. (1964)—A study of the relationships between the yield of irrigated lucerne and the properties of grey and brown soils of heavy texture in south west N.S.W. *Australian Journal of Soil Research.* **2**: 96-110.

MYERS, L. F. (1967)—Assessment and integration of special purpose pastures. 1. Theoretical. *Australian Journal of Agricultural Research.* **18**: 235-44.

ROBARDS, G. E., and WILSON, A. D. (1967)—The *in vitro* digestibility of oesophageal fistula samples washed for botanical separation. *Australian Journal of Experimental Agriculture and Animal Husbandry.* **7**: 22-24.

SMITH, R. (1945)—Soils of the Berriquin Irrigation District of N.S.W. *C.S.I.R.O., Australia, Bulletin No. 189.*

SQUIRES, V. R. and MYERS, L. F. (1968)—Evaluation of four warm-season perennial grasses under grazing in irrigated swards. Proceedings of Australian Grasslands Conference 4: **2b**.

[Accepted for publication: March 20, 1970]