Poor persistence of sub-tropical grasses over winter

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Abstract

There are a number of challenges with growing sub-tropical (C4) perennial grasses in a Mediterranean environment especially with respect to persistence over summer. Despite these challenges, sub-tropical grasses are showing good potential in many areas of south-western Australia. However, there are questions about their adaptation to regions with cool-wet winters.

Results from two trials near Kojonup are compared with those from Badgingarra. The Kojonup trials were established in spring 2003 and 2004 and most lines persisted well over the first summer and grew strongly in autumn. However, there was a high mortality over winter especially of the bunch grasses. Kikuyu was unaffected with almost 100% groundcover in spring while the diploid Rhodes grass varieties had some survival. At Badgingarra there was good persistence over winter of all species.

The trial results from Kojonup provide clear evidence of a ‘cold zone’ in WA where there is poor persistence of many sub-tropical grasses over winter. The poor persistence is due to a combination of cold, wet soils and frosts. The ‘cold zone’ has been spatially defined from maps of July-August mean minimum temperature and frost frequency and its implications are discussed.

Key words

Rhodes grass, kikuyu, winter survival, cold zone, C4 grasses

Introduction

There is increasing interest in growing sub-tropical (C4) grasses in south-western Australia for producing out-of-season green feed, smoothing out the annual feed profile, increasing water use and reducing wind erosion. In spite of the apparent difficulty of growing summer-active species in a region with a Mediterranean climate, sub-tropical grasses are showing considerable promise, especially on the south and west coasts and in the northern agricultural area. They are being successfully grown on deep sands which are marginal for growing annual crops due to low water-holding capacity and poor fertility.

A major challenge with growing C4 grasses in the WA environment is persistence over summer when there can be extended periods of hot, dry conditions for 4 to 7 months. Some of the species are showing good resilience and an ability to persist and be productive in areas where the annual rainfall is greater than 450-500mm. However, there was anecdotal evidence to suggest that persistence of C4 grasses over winter in the ‘Great Southern’ region of WA may be problematic.

Jones (1969) reported death of some C4 grasses over the first winter in south-east Queensland in a region with both frequent and severe frosts. In this study there was very good survival of Pioneer Rhodes grass (*Chloris gayana*) with 97% survival, while the two varieties of setaria (*Setaria sphacelata*) and bambatsi panic (*Panicum coloratum*) all had less than 24% survival, while Petrie or green panic (*Panicum maximum*) had very poor survival (0-6%). There was no evidence of mortality of kikuyu (*Pennisetum clandestinum*) or paspalum (*Paspalum dilatatum*). In these experiments the grasses were sown in mid- to late summer and the plants were still relatively small at the start of winter. Mortality was related to the frost tolerance of first year plants. A number of studies have tested the frost susceptibility of C4 grasses and the conditions which either reduce or exacerbate frost damage (e.g. Ivory and Whiteman 1977). Frost damage of C4 grasses usually refers to the proportion of the foliage which has been killed, while reports of whole plants being killed is uncommon (Hacker *et al*. 1974).

Two trials were established to study the persistence and production of a range of C4 grasses in this environment. The results from these trials are compared with a trial at Badgingarra in the West Midlands north of Perth which has a similar annual rainfall but has milder winters with a low frost risk.

Methods

The main aim with the trials was to assess a range of species for persistence and production. The first trial established in 2003 near Kojonup was part of a G x E study of perennial grasses across southern Australia under the umbrella of the CRC for Plant-based management for Dryland Salinity - National Field Evaluation Project. The trial included a range of temperate and sub-tropical perennial grasses, with 4 replicates in a randomised block design. The trial is located mid-slope on a yellow/brown shallow loamy duplex.

The trials established in 2004 south-west of Kojonup and at Badgingarra Research Station were part of a series of trials across south-western Australia to measure seasonal profiles in terms of both quantity and quality for a range of C4 grasses (Joint project between DAFWA, Evergreen-AWI and MLA). The trials were row-column designs with 3 replicates and 7 m x 3.6 m plots. The Kojonup-2004 trial is on a duplex sandy gravel on the lower slope. The Badgingarra trial is on a yellow deep sand on a lower slope.

The trials were sown with an experimental cone seeder especially developed for sowing small-seeded species. The C4 grasses were sown in early to mid-September when the soil temperatures were favourable. The C4 grasses included: digit grass (*Digitaria eriantha*), panic grass (*Panicum maximum*), setaria (*Setaria sphacelata*) and signal grass (*Urochloa decumbens*) which are all bunch grasses plus Rhodes grass (*Chloris gayana*) which has a stoloniferous growth habit and kikuyu (*Pennisetum clandestinum*) which has both stolons and rhizomes.

Establishment counts were undertaken 6-8 weeks after seeding using two randomly placed quadrats (100cm x 15cm) per plot. Permanent quadrats (80 cm x 50 cm with 10 cm x 10 cm grid cells) were installed in representative areas of each plot (2003 – one quadrat per plot; 2004 - three per plot) to monitor persistence. For persistence, both plant number and frequency (i.e. presence or absence of tillers in each grid cell) were measured at the start of summer, in autumn and again in spring of year2. Only frequency was measured at the Kojonup-2003 site.

Biomass was measured opportunistically over summer-autumn and every 4-6 weeks during the growing season. After each assessment the plots were either crash grazed or mown to a height of 5cm or 8cm depending on growth habit. A sub-set of the treatments representing the main species and varieties of C4 grasses grown commercially in WA were included in the analysis. Not all of the lines were present in the Kojonup-2003 trial.

Results

Excellent establishment was achieved at all three sites with a high plant density at the end of the first spring. At Kojonup-2003, 48mm of rainfall in January resulted in good summer production with Katambora Rhodes grass, Narok setaria and Petrie panic producing 3.6, 2.5 and 2.3 t DM/ha by March 2004 respectively.

The persistence results from Kojonup-2003 show there was a high mortality of the bunch grasses over the first winter, with few plants of Narok setaria and Petrie panic surviving (Table1). With the Katambora Rhodes grass there was a sharp decline over the first winter, but it then spread from runners over spring to have 58% groundcover in December. The Rhodes grass density again declined over the second winter and has now died out. On the other hand, the persistence of kikuyu was unaffected over winter and it maintains full groundcover.

Table 1. The persistence (av. frequency %) of the C4 grass treatments in the Kojonup-2003 trial. Bunch grasses are denoted with a (B).

Grasses	June ‘04	Sept. ‘04	Dec. ‘04	May ‘05	Sept. ‘05	May ‘06
Katambora Rhodes grass	94	18	58	51	16	0
Narok setaria (B)	93	10	15	33	6	6
Petrie (green) panic (B)	75	11	1	3	2	1
Whittet kikuyu	98	92	98	100	99	100
LSD 0.05	18.7	17.7	35.0	39.5	9.6	4.8

The Kojonup-2004 trial had very good to excellent establishment of all treatments with 35 to 77 plants/m^2. A dry summer was followed by good rain in late March to early April (125mm over 3 days). The C4 grasses grew strongly in autumn with most lines producing between 2.0 and 3.1 t DM/ha by mid-May. Petrie (green) panic and Splenda setaria both produced 3.1 t DM/ha.

Table 2. Persistence of the C4 grasses in terms of plant number and frequency for the Kojonup-2004 trial. Bunch grasses are denoted with a (B).

Grasses	Av. plant frequency (%)				Av. plant number (plants/m^2)			
	Nov. ‘04	May ‘05	Dec. ‘05	% survival over winter	Nov. ‘04	May ‘05	Dec. ‘05	% survival over winter
Callide Rhodes	73	99	3	3	39	48	1	2
Gatton panic (B)	69	59	0	0	87	41	0	0
Katambora Rhodes	89	94	58	62	48	52	19	37
Petrie (green) panic (B)	78	76	0	0	101	45	0	0
Premier digit grass (B)	80	74	0	0	151	54	0	0
Narok setaria (B)	78	69	20	29	71	30	7	22
Signal grass (B)	84	68	0	0	51	33	0	0

Splenda setaria (B)	79	75	2	2	74	32	1	3
Whittet kikuyu	75	96	100	104	52	67	52	77
LSD 0.05	17.8	15.3	23.1		44.1	17.5	7.2	

The persistence results from Kojonup-2004 show some loss of plants over summer but the plant densities were very high at the start of summer, so the plant density in autumn was still more than adequate (30 to 67 plants/m^2) for maximum production in this environment. There was a high mortality of all the C4 grasses over winter except for kikuyu and to a lesser extent Katambora Rhodes grass. Narok setaria had the best winter survival of the bunch grasses with 22% of the plants surviving, but most had nil or very low survival (Table2).

At Badgingarra, the summer conditions were very hot and dry and all plants were stressed from January to March. There was a decline in plants numbers for some species over this period, with the most marked reduction in plant density for Splenda setaria and Premier digit grass. There was good rain in late March-early April (40mm) followed by a wet May (124mm) which resulted in excellent autumn growth of most species with ~4.6t DM/ha for Rhodes grass and 3.2-3.5t DM/ha for the panic grasses.

The persistence data from Badgingarra show good survival over winter of the bunch grasses with >78% persistence for all treatments in terms of plant number, however in terms of frequency which reflects the size of the individual plants, only signal grass was under 100% (Table3).

Table 3. Persistence of the C4 grasses in terms of plant number and frequency for the Badgingarra-2004 trial. Bunch grasses are denoted with a (B).

Grasses	Av. plant number (plants/m^2)				Av. plant frequency (%)			
	Dec. ‘04	May ‘05	Dec. ‘05	% survival over winter	Dec. ‘04	May ‘05	Dec. ‘05	% change over winter
Callide Rhodes	16	24	23	93	41	59	85	144
Gatton panic (B)	19	18	16	91	39	42	55	130
Katambora Rhodes	19	34	29	85	43	62	97	155
Petrie (green) panic (B)	37	23	20	88	42	37	50	136
Premier digit (B)	28	12	10	84	28	24	33	139
Signal grass (B)	22	14	11	78	32	41	37	91

Splenda setaria (B)	21	8	6.5	79	28	21	23	108
Whittet kikuyu	26	21	25	120	39	59	96	163
LSD 0.05	14.4	10.2	6.3		12.9	20.4	16.0	

Discussion

There was poor persistence of the C4 bunch grasses over winter at the two Kojonup trials. At both sites the grasses had grown well either over summer (Kojonup-2003) or autumn (Kojonup-2004) and were well established before the start of winter, however a high proportion of the plants died over winter. The C4 grasses were burnt by the first frosts in winter, but instead of recovering in spring as the temperature increased a high proportion of the grasses, especially the bunch grasses had died over winter.

The initial density in the Badgingarra trial was considerably higher than in most commercial paddocks, so even though the density decreased over the dry summer there was still a good plant density in autumn. In terms of plant number there was a small loss over winter with most treatments, but the remaining plants more than compensated by increasing in size and hence the frequency increased (Table4). The only exception was signal grass which is sensitive to low temperatures. At this site the winter conditions are comparatively mild and while growth is checked in July and early August, frosts are uncommon.

Some of the potential reasons for the grasses dying over winter in the Kojonup trials can be excluded. The plants were not moisture stressed or waterlogged. Some C4 grasses are susceptible to waterlogging, however the two Kojonup sites are moderately well drained and the presence of annual volunteer weed species like capeweed (*Arctotheca calendula*) which has a low waterlogging tolerance indicates waterlogging was not a major factor. The mortality over winter was probably caused by a combination of multiple stresses, in particular infrequent frosts and prolonged exposure to cold-wet soils. Competition from annual weeds and severe grazing prior to winter (Kojonup-2003) may also have been contributing factors. There was strong competition from annual pastures and volunteer weeds, but this also occurs at other sites where C4 grasses show good persistence.

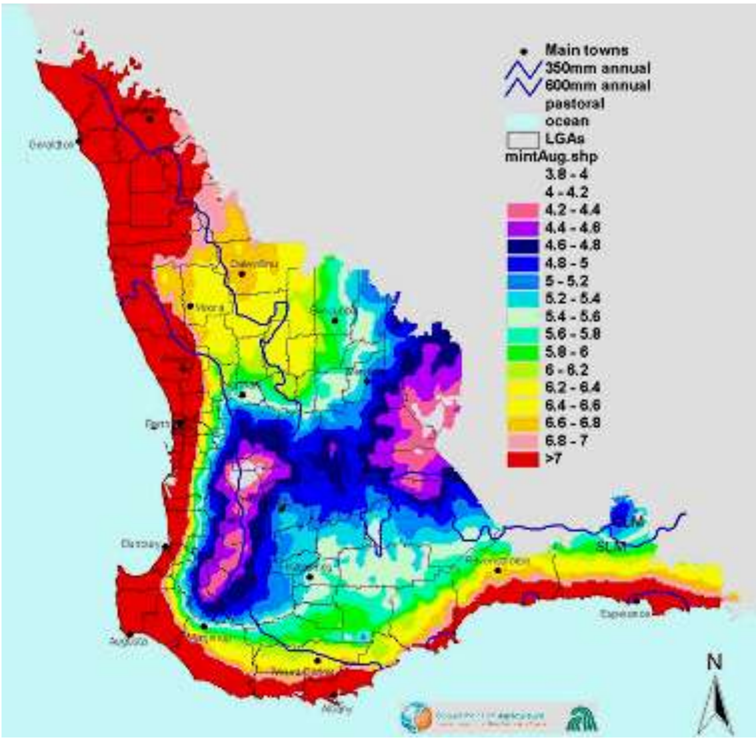

Figure 1. The mean minimum temperature (?C) for August shows a distinct 'cold.

The results presented show strong evidence of a 'cold zone' in the Kojonup district where there is poor persistence over winter of most C4 grasses and in particular the C4 bunch grasses. To spatially define the 'cold zone' data from the Bureau of Meteorology was spatially extrapolated across the agricultural area of Western Australia on a one km grid. Maps of frost frequency in July and August plus average minimum temperature in July and August all show an area in the Great Southern and the central wheatbelt which is both colder and more prone to frosts than surrounding districts. The main part of this cold zone is clearly defined by the area where the mean minimum temperature in August is less than 5.2?C (Figure1), however the boundary is less clear. The extent of the cold zone probably fluctuates between years depending on seasonal conditions, with some areas only affected occasionally. This still has implications for the longevity of C4 perennial grass pastures in these areas as ideally they would persist for at least 6-10 years.

In the main part of the cold zone which extends almost from Northam in the north to Manjimup in the south and to the eastern boundary of the agricultural area the C4 grass options appear to be limited. Kikuyu is an option in areas receiving >500-550mm. Two other C4 grasses with rhizomes are naturalised in the high rainfall areas of the cold zone; paspalum (*Paspalum dilatatum*) and Bermuda couch grass (*Cynodon dactylon*). The longevity of C4 bunch grass pastures, with the possible exception of 'Consol' lovegrass would appear to be limited by poor persistence over winter. New species of C4 grasses for this area would most likely require a rhizomatous growth habit to ensure good persistence over winter.

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