Frontier balansa clover offers exciting prospects for low rainfall pastures in Western Australia

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ABSTRACT

Balansa clover (*Trifolium michelianum*) is well adapted to waterlogged, mildly saline soils. Frontier is a new cultivar that is earlier flowering than the existing cultivars Paradana and Bolto. This paper reports agronomic data from a number of field sites in Western Australia which compare the performance of Frontier and Paradana together with some other common legumes. Frontier flowers 80-85 days after sowing which is three to four weeks earlier than Paradana. Seed production was similar to Cyprus barrel medic but significantly higher than Paradana. Seedling densities of Frontier and Paradana were highest in permanent pasture. Productivity of both cultivars after a cereal crop was low, possibly due to the inability to maintain an adequate pool of hard seeds and poor seedling vigour. The herbicide tolerance of Frontier was similar to Dalkeith subterranean clover with acceptable tolerance to Broadstrike?, Spinnaker?, trifluralin, and Tigrex?. Frontier offers exciting potential for low rainfall pastures in Western Australia (350 – 450 mm annual rainfall).

KEY WORDS

Legume, balansa clover, seed production, hard seed, regeneration, herbicide tolerance.

INTRODUCTION

Balansa clover (*Trifolium michelianum*) is an annual, cross-pollinated legume pasture species naturalised in the Mediterranean basin. Its main attributes are its high tolerance to clover scorch (*Kabatiella caulivora*), its prolific seed production and its tolerance to waterlogged conditions and mildly saline soil (1, 4), especially as mature plants (2). The species has been developed by the South Australian Research and Development Institute (SARDI) and existing cultivars include Paradana released in 1985 and Bolto released in 1998. Paradana has a mid-season maturity and has been used successfully in Western Australia but only in the western margin of the cereal belt (>400 mm annual rainfall).

The development of new cultivars to expand the range of balansa clover has been a priority of the National Annual Pasture Legume Improvement Program for several years. Frontier is 2-3 weeks earlier flowering than Paradana and was released in 2000 with a commercial arrangement between SARDI and SGB - Seed Grain and Biotechnology Australia (1, 3). Frontier is a cultivar comprised of 20 individual lines that were originally based on single plant selections from Paradana and evaluated individually before being recombined in equal quantities to form the new cultivar. It is aerial seeding, seed is shed at maturity and seed size is generally < 1mg/seed. Its appearance is quite variable, displaying a range of leaf markers. In South Australia, Frontier has performed well on a variety of soil types with pH ($CaCl_2$) between 4.8 – 7.6. Its seedling regeneration and early season production has on occasion been superior to Paradana and it has shown excellent persistence under grazing (1). There is limited information about the performance of Frontier in Western Australia. This paper reports results from three field experiments that examine the productivity of Frontier compared with Paradana, together with its tolerance to herbicides.

MATERIALS AND METHODS

Experiment 1

Four pasture legumes adapted to fine textured soils were sown at an experimental site near Cunderdin, Western Australia (31? 40′ S, 117? 16′ E) in June 1998. The soil was a grey, sandy loam (pH $CaCl_2$ 5.1,

Org C 1.0%, EC 0.07 dS/m, P 31 ppm, K 194 ppm) over clay (pH $CaCl_2$ 7.8, EC 0.19 dS/m). The plots were 6m x 25m and treatments were replicated three times in a randomised block design. The cultivars were *T. michelianum* cvv. Frontier and Paradana, *T. resupinatum* cv. Persian Prolific and *M. truncatula* cv. Cyprus. They were sown into a weed-free seedbed at a rate of 12 kg/ha with 10 kg/ha P and topdressed with 25 kg/ha K three weeks after seeding. Red-legged earth mite and aphids were controlled with insecticide during the year and annual grasses were controlled with a selective grass herbicide. The plots were ungrazed during the growing season but dry residues were intensively grazed during early March 1999. Half of each plot was cropped to wheat in June 1999 and the remainder allowed to regenerate to pasture. Cereal plots were cultivated to a depth of 5-6cm and seeded on the same day with a 12-run combine into a weed-free seedbed. No in-crop herbicides were required and crops were harvested. Pastures were ungrazed during the growing season but dry residues and cereal stubbles were intensively grazed during late summer in 2000. All sub-plots were allowed to regenerate to pasture in 2000. Measurements included days to flowering (when approx. 100 flowers/m^2), herbage production in the establishment year, seed production and seedling regeneration. Data was analysed by spatial analysis.

Experiment 2

A field experiment was conducted at Shenton Park, near Perth (31? 56' S, 115? 50' E) to examine the pattern of hard seed breakdown in a range of annual legumes. Only results for Frontier, Paradana, and Dalkeith subterranean clover are reported in this paper. Newly ripened seed was collected in December 1998 from another field experiment near Cunderdin and removed from seed heads by hand rubbing to prevent scarification. Two hundred seeds were placed in each of 28 gauze envelopes per cultivar and pinned to the bare soil surface in January 1999. Duplicate envelopes were sampled fortnightly over the next 7 months. Residual hard seed was measured after germination in petri dishes at 20°C for two weeks.

Experiment 3

Eleven pasture legumes were sown at an experimental site near Goomalling, Western Australia (31? 21′ S, 116? 53′ E) on 10 June 1999. Only the results for *T. michelianum* cvv. Frontier and Paradana and *T. subterraneum* cv. Dalkeith are reported in this paper. The soil was a red-brown sandy loam (pH $CaCl_2$ 4.8). The plots were 2m x 46m and cultivar treatments were replicated three times in a randomised block design. Cultivars were seeded at 25 kg/ha into a weed-free seed bed with 8 kg/ha P and 27 kg/ha K. Red-legged earth mite and aphids were controlled with insecticide during the year. A range of herbicide treatments (see Table 4) was applied at right angles across the cultivars with a spray width of 2m. Herbicides were randomised in each replicate. All post-emergent herbicides were applied on the 3 August 1999 at the 6-leaf stage of the pasture. Paraquat (Gramoxone$^{?}$) was also applied as a spray-topping treatment on 23 September 1999. Plots were ungrazed and were maintained in a weed-free condition to avoid confounding weed competition with herbicide reaction. Plots were visually rated in August and September for effects on herbage production and clean seed yields were measured in December.

RESULTS

Experiment 1

Frontier balansa clover commenced flowering about the same time as Cyprus barrel medic and was 20 days earlier flowering than Prolific Persian clover and 26 days earlier than Paradana (Table 1). There was no difference between the three clover cultivars in final herbage production but seed production was significantly higher in Frontier and comparable to Cyprus (Table 1). A considerable germination occurred in March 1999 (Table 2), however, many seedlings failed to survive until the true break of season in May.

Table 1. Days to flower, legume dry matter (t/ha) and clean seed yield (kg/ha) of four pasture legumes in the establishment year.

Species/Cultivar	Days to flower	Dry matter (t/ha) 14/9/98	Dry matter (t/ha) 1/10/98	Seed yield (kg/ha)
Frontier balansa clover	85 (28 Aug)	2.57	2.69	426
Paradana balansa clover	111 (23 Sept)	2.20	2.54	272
Prolific Persian clover	105 (17 Sept)	2.20	2.72	174
Cyprus barrel medic	87 (30 Aug)	2.05	3.26	511
l.s.d. (*P*=0.05)		0.39	0.31	150

Table 2. Seedling densities (plants/m^2) of four pasture legumes regenerating over three consecutive years and after a wheat crop. Means followed by the same letter are not significantly different (P<0.05).

Species/Cultivar	Density Yr 2 29/3/99	Density Yr 2 24/6/99	Density Yr 3 20/7/00	Density after crop 20/7/00
Frontier balansa clover	4267	7818 *a*	12682 *a*	674 *a*
Paradana balansa clover	3672	3425 *b*	12193 *a*	323 *b*
Prolific Persian clover	3360	1295 *c*	1451 *b*	135 c
Cyprus barrel medic	3465	1937 *b*	1658 *b*	387 *b*
	ns			

There was little further germination in Cyprus and Prolific and pastures were mainly comprised of plants surviving from the March germination. In contrast, further germination of both balansa clovers was observed, notably in Frontier (Table 2). Seedling densities of regenerating balansa clover continued to increase into the third year and were significantly higher than Prolific or Cyprus, although Cyprus plants showed greater seedling vigour. Seedling densities for pastures regenerating after crop were substantially lower in all cultivars. Densities were highest for Frontier (Table 2) although it was apparent that early production was greatest for Cyprus due to superior seedling vigour.

Experiment 2

Initial levels of hard seed were relatively high for all cultivars. Hard seed breakdown (seed softening) over the first summer/autumn was rapid (Table 3) and both balansa clover cultivars had final hard seed levels in June around 10%. The majority of this softening had occurred by the 5 April.

Table 3. Decline in hard seed (%) for three legumes after one summer/autumn on the soil surface.

Species/Cultivar	Residual hard seed (%)					
	11 Jan 99	8 Mar 99	22 Mar 99	5 April 99	31 May 99	14 Jun 99
Frontier balansa clover	86	28	30	15	3	4
Paradana balansa clover	90	57	63	26	8	13
Dalkeith sub. clover	79	36	24	18	16	20

Experiment 3

The herbicide tolerance of Frontier was generally similar to Paradana with notable exceptions being a higher sensitivity to both MCPA and the paraquat spray-topping treatment (Table 4). Herbicide reactions in balansa clover were also similar to Dalkeith subterranean clover, although Dalkeith was more tolerant of glyphosphate and Spinnaker?. Herbicide treatments with the least impact on dry matter in balansa clover were Broadstrike?, Spinnaker?, Tigrex? and trifluralin, although trifluralin was observed to reduce plant numbers. Simazine also appeared to have little impact but an increasing level of damage was apparent throughout spring. The balansa clovers showed a strong capacity to recover after mid-winter paraquat application but seed yields appear to be reduced with its use as a spray-topping treatment. The greatest reduction in dry matter in balansa clover occurred with glyphosate, bromoxynil, Jaguar? and MCPA. However, favourable conditions in spring allowed seed production to be maintained at high levels in all these treatments except bromoxynil.

Table 4. Percentage decline in herbage production of three pasture legumes at two times during the 1999 growing season (August and September) following herbicide application. Seed yields (SY) are expressed as a percentage of unsprayed yields.

Herbicide/Rate (concentration of active ingredient)	Frontier balansa clover			Paradana balansa clover			Dalkeith sub. clover		
	Aug	Sept	SY	Aug	Sept	SY	Aug	Sept	SY
				Pre-emergent					
Trifluralin 1.5 L/ha (400)	37	22	118	37	35	132	20	24	100
				Post-emergent					

Glyphosate 0.4 L/ha (450)	62	80	114	51	81	111	40	54	91
Paraquat 0.5 L/ha (250)	49	33	120	43	38	107	55	53	102
Simazine 0.75 L/ha (500)	6	22	96	5	28	121	8	18	77
MCPA (amine) 1.0 L/ha (500)	52	50	104	34	39	105	25	39	82
Bromoxynil 1.5 L/ha (200)	55	45	67	48	39	82	34	48	81
Jaguar? 0.5 L/ha (250/25)	46	42	114	48	43	112	32	47	68
Tigrex? 0.4 L/ha (250/25)	26	9	93	23	14	124	11	13	101
Broadstrike? 25 g/ha (800)	16	6	86	14	5	118	7	12	107
Spinnaker? 0.25 L/ha (240)	27	16	168	26	18	101	8	9	95
Diuron 0.2L/ha (500)+2,4DB 0.4L/ha (400)	21	18	69	25	24	90	18	38	76
				Spray-top					
Paraquat 0.5 L/ha (250)			47			81			76
Dry matter (t/ha) or seed yield (kg/ha) – Unsprayed treatment	2.0	7.7	892	1.9	6.9	847	1.0	4.0	1400

DISCUSSION

The capacity of Frontier to flower 26-30 days earlier than Paradana is consistent with differences reported in South Australia (3). However, both varieties appear to flower considerably earlier in Western Australia than in South Australia. Frontier in particular appears to flower about 30 days earlier in Western Australia (85 days cf. 118 days). The reason is unclear but is unlikely to be due entirely to the methodology of measurement. It maybe related to higher latitudes in Western Australia and/or warmer winter temperatures. This early maturity makes Frontier particularly well suited to the low rainfall regions (>350 mm annual rainfall) of the cereal belt in Western Australia. The higher seed production of Frontier compared to Paradana is consistent with its earlier maturity and seed production should be more reliable between years. It may also be productive in regions with 300 to 350 mm annual rainfall as the effective length of growing season in low lying, wet areas of the landscape will be longer than that dictated by annual rainfall alone.

Frontier has the capacity to regenerate strongly in permanent pasture and the increasing densities in successive years of pasture is consistent with high seed production and a relatively rapid rate of seed softening. Maintaining high seed pools will be important for the productivity of Frontier in saline soil as

poor establishment and poor seedling vigour can be a major limitation (2). The substantially poorer regeneration and low productivity after a cereal crop is cause for concern. This may be due to burial of the seed pool to depths too great for seedling emergence but is more likely to be due to the rapid rate of seed softening over a single summer/autumn. As a consequence most seeds germinate in the year of crop and are killed. The high seed production in Frontier does not appear to compensate for rapid seed softening and there may be insufficient hard seed remaining in the seed pool for self-regeneration after the cropping phase. Standard management practice to encourage maximum regeneration of balansa clover pasture involves hard summer grazing (4). This practice is designed to remove dry plant residues that otherwise insulate the seed and prevent exposure to high soil temperatures which bring about seed softening. We suggest that if Frontier pastures are to be cropped, dry residues should be retained as long as possible to slow the rate of seed softening. Grazing should be delayed until late autumn and only enough residue removed to allow the passage of seeding machinery. The extent of seed softening in Dalkeith subterranean clover was greater than anticipated and this is probably related to the use of free seed rather than seed retained in the burr. Free seed is likely to be exposed to greater fluctuations in temperature but its use is appropriate for balansa clover, which sheds most of its seed at maturity.

Several herbicide options appear suitable for Frontier balansa clover. Broadstrike?, Spinnaker? and Tigrex? should provide control of most broadleaf weeds although they are reasonably expensive. We suggest that lower rates of MCPA (500-750 ml/ha) could be used as a spray-graze option to provide low cost weed control in balansa clover with some reduction in early season productivity. The recovery of balansa after midwinter paraquat application was notable but the loss of early herbage production is probably too severe for this to be considered as a low cost grass control option. Given its early maturity, the substantial reduction in seed yield of Frontier after spray-topping is surprising, but may have been a consequence of a reduced capacity for regrowth after spraying. Simazine should be used with caution given the apparent increase in damage during the growing season. Damage is likely to be more severe on sandier soils. Trifluralin will be useful for the control of ryegrass in new plantings.

CONCLUSIONS

Frontier balansa clover has the capacity to make a substantial contribution to pastures in the low rainfall cereal belt of Western Australia. Its performance will be best in permanent pasture but attention to grazing management should enable adequate self-regeneration after a single cropping phase.

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REFERENCES

1. Craig, A. D. and Rowe, T. D. 2000. SARDI Technote No. 4. (PIRSA: South Australia)

2. Rogers, M. E. and Noble, C. L. 1991. *Aust. J. of Agric. Res.* **42**, 847-57.

3. SGB Fact Sheet 1999. Frontier balansa clover – providing crop and pasture management options.

4. Snowball, R. 1994. In “Alternative Pasture Legumes 1993”. (Eds D. L. Michalk, A. D. Craig and W. J. Collins) *Department of Primary Industries South Australia, Technical Report 219*. pp. 111-14.