Trigonella balansae – a new pasture legume for the alkaline soils of southern Australia?

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ABSTRACT

Dry matter production of *Trigonella balansae* was shown to be comparable to a number of annual medics (*Medicago* spp.) at Bute, South Australia. The average seed yield of *T. balansae* across three locations in South Australia was 429 kg/ha. In a grazing experiment in which sheep were allowed to ingest seed from a mature standing pasture of *T. balansae*, the rate of seed depletion declined after 3 days, with 39% (257 kg/ha) of the seed reserve still remaining after 14 days grazing. Plant density in the regenerating pasture was 800 plants/m^2 indicating the species should tolerate moderate grazing pressure after seed set. An examination of the symbiotic performance of *T. balansae* found that the plant was nodulated by the rhizobia in 23 of the 27 soils surveyed. The symbiosis was generally effective in nitrogen fixation, with the soil rhizobia resulting in 61% of the shoot DM of a highly effective pure strain (RRI128) of *Rhizobium meliloti*. A herbicide study indicated that *T. balansae* may be less tolerant than Herald medic to several commonly used herbicides.

KEY WORDS

Trigonella balansae, pasture, nitrogen fixation, *Rhizobium meliloti*, herbicide tolerance, grazing.

INTRODUCTION

Soils of alkaline reaction in temperate Australia, receiving between 250 and 400mm annual rainfall, are used for both cereal and livestock production. Traditionally, both naturalised and sown species of annual medics (*Medicago spp*.) have been the most important, and dominant, pasture legume in this zone. Medics are typically used in one to two year rotations with cereal crops, where they are valued for their ability to fix nitrogen which becomes available to following cereal crops, their role in reducing the impact of cereal root diseases, and the provision of high quality livestock feed.

However, in recent times the merit of relying solely on annual medics as the pasture base has been questioned. This has occurred due to the perceived poor performance of the medic pastures in some regions and has been exacerbated by the high cost of medic seed, particularly the newer aphid resistant cultivars. There has also been the recognition that increased pasture diversity is ecologically desirable.

As a result, Australian pasture evaluation programs have been examining a wide range of pasture genera for their ability to complement and add diversity to the medic pasture base. Halloran and Pennell (2) identified the genus *Trigonella* as having potential in Australian farming systems. *Trigonella balansae* Boiss. and Reuter, (1,4) an annual legume of Eurasian origins, has shown promise in more recent trials. It is both productive and able to regenerate on alkaline soils receiving <400mm annual rainfall. Importantly, its upright growth habit and proliferation of seedpods at the top of the canopy make it amenable to low cost seed production (3). This should aid its adoption by farmers, relative to the more expensive seed of annual medics.

This paper examines some key agronomic attributes which are likely to have a bearing on the success of *T. balansae* in alkaline soil farming systems.

RESULTS AND DISCUSSION

Dry matter production and seed yield

The field performance of a range of *T. balansae* accessions was compared with selected annual medic cultivars. At three locations in South Australia mean flowering time for the *T. balansae* accessions was on average 1 to 2 weeks later than the medics. As a group, the early dry matter production (to September) and seed yields of *T. balansae* were comparable to those of the annual medics (Table 1). At each of the sites there were *T. balansae* accessions that were more productive than the annual medic cultivars.

Table 1. Mean dry matter (DM, kg/ha) and seed yield (SY, kg/ha) of *T. balansae* accessions (range shown in parentheses) and selected annual medic cultivars at three sites in South Australia.

Species	Identity	[1]Bute (375mm, pH_w 7.6, sandy loam)		[1]Mallala (380mm, pH_w 7.8, loam)	[1]Mannum (310mm, pH_w 8.1, sandy loam)
		DM	SY	SY	SY
T. balansae	Various	1095 (297-1563)	300 (79-472)	528 (325-879)	460 (246-702)
M. littoralis	Herald	528	164	436	591
M. polymorpha	Santiago	388	299	480	513
M. truncatula	Caliph	-	-	441	560
M. truncatula	Mogul	924	313	-	-

[1] *T. balansae* means based on 15 accessions at Bute and 12 accessions at Mallala and Mannum

Although the early growth of *T. balansae* appears promising relative to the annual medics, this was is in the absence of grazing. Given the upright growth habit of *T. balansae*, particularly at the seedling stage, there are concerns it may be less tolerant of winter grazing than the annual medics. There are also concerns that the *T. balansae* germplasm available for evaluation may not flower early enough. This could be a significant disadvantage in the lower and more erratic rainfall areas of the cereal-livestock zone. Both of these issues are currently under investigation.

Regeneration after summer grazing

The effect of summer grazing by sheep on the seed reserves of three pasture legume species (Table 2) was assessed. Plots (15 x 13m) of mature standing herbage of each of the pasture species were grazed with 3 sheep in each plot in January 2000 for 14 days at Turretfield Research Centre (470mm, pH_w 7.0, red-brown earth). Subsequent regeneration (March 2000) and winter herbage production (July 2000) were measured.

Before grazing, the seed reserves exceeded 550 kg/ha for each legume species (Table 2). Although more than 50% of the seed reserve of all 3 pasture species were ingested during the 14 days grazing, for *T. balansae* and *Trifolium michelianum,* most of the seed was eaten during the first 3 days of grazing (310 and 325 kg/ha available seed at Day 3, respectively). Presumably this occurred because the small seed (<1.5mg/seed) of these two species is difficult for the sheep to access once it has fallen from the legume pod. *Trifolium michelianum* seed was better able to survive ingestion (65 kg/ha seed recovered from faeces) by the sheep than the seed of T*. balansae* and *Medicago truncatula* (<12 kg/ha recovered from faeces).

Table 2. Effect of grazing by sheep on the seed reserves (kg/ha), regeneration (no. plants/m^2) and dry matter production (kg DM/ha) of three annual pasture legumes.

Legume identity	Available seed before grazing	Seed ingested during grazing	Seed escaping ingestion	Viable seed recovered from sheep faeces	Pasture regeneration after grazing	Dry matter production
T. balansae Line SA5045	663	406	257	11	800	2990
M. truncatula cv. Mogul	631	335	296	10	108	2960
T. michelianum cv. Paradana	589	323	266	65	2027	2030

Despite the inferior survival of *T. balansae* in sheep faeces, there were still sufficient reserves of germinable seed on the ground to produce 800 plants/m^2 in the regenerating pasture, following early rain (20-21 February 2000). Subsequent winter herbage production (2990 kg/ha) of the regenerating *T. balansae* pasture was similar to that of *M. truncatula*. *Trigonella balansae* should persist following moderate grazing of dry residues over summer.

Symbiotic performance

Four-day-old seedlings of *T. balansae* (three accessions), growing in a nitrogen free potting media were inoculated with extracts from 27 soils. There were also four controls (two pure strains of *Rhizobium meliloti*, uninoculated and mineral nitrogen treatments). Shoot weight was assessed after 5 weeks and used as an index of the nitrogen fixation capacity of the symbiosis. The number of rhizobia able to nodulate *T. balansae* was estimated in each soil (5) using *T. balansae* (SA 5045) as the trap plant.

Both strains of rhizobia (SU277 and RRI128) resulted in significant and large increases in shoot growth compared to the uninoculated treatment (Table 3). Strain RRI128 (AL commercial inoculant in 2000) performed consistently well with all three *T. balansae* accessions and overall resulted in greater shoot growth (98mg) than the traditional *Trigonella* inoculant, SU277 (72mg).

Twenty-three of the 27 soils contained more than 100 rhizobia/gram, which is probably sufficient for the prompt nodulation of *T. balansae* in the field. Number of rhizobia in the soil was correlated (r=0.51, P=0.006) with soil pH_{Ca}. The four soils (1?SA and 1?VIC and 2?WA) which had <100 rhizobia/gram had a pH_{Ca} of less than 6.5, indicating that rhizobial inoculation should be encouraged where *T. balansae* is to be sown on soils below this pH threshold.

When soils containing >100 rhizobia/gram are considered (Table 3), the naturalised soil rhizobia were generally effective at nitrogen fixation. On average, these soil treatments resulted in 63% (61mg) of the shoot weight of strain RRI128 (98mg). Only 2 soil treatments (1?VIC and 1?WA) resulted in <50% of the shoot weight of strain RRI128, but still produced 3-fold the shoot weight of the uninoculated treatment. All three accessions of *T. balansae* formed an effective symbiosis across the range of soil rhizobia.

Table 3. Description of the inoculation treatments and their effect on the shoot weight of three accessions of *Trigonella balansae.* Data is based on soils with >100 rhizobia/g soil.

There was no significant interaction between inoculation treatment and *T. balansae* accession. Means of the inoculation treatments containing the same letter are not significantly different based on the 5% LSD.

Description of inoculation treatment	Number of soils	Mean soil pH ($CaCl_2$)	Mean number of rhizobia (no./g soil)	Mean shoot weight (mg DM /plant)			
				SA5045	SA32999	SA33025	Mean
Uninoc.	-	-	-	11	14	15	14 a
+ Nitrogen	-	-	-	78	107	80	88 ef
SU277	-	-	-	73	82	59	72 cde
RRI128	-	-	-	86	98	111	98 f
SA soils	12	7.6	10,054	64	78	77	73 d
VIC soils	5	6.9	9,324	55	58	77	63 bc
WA soils	2	5.8	1,013	52	46	56	51 b
NSW soils	4	6.3	22,742	55	61	58	58 b

Herbicide tolerance

The tolerance of an accession of *T. balansae* (SA 5045) to a range of herbicides was compared with *M. littoralis* (cv. Herald) in a glasshouse experiment. Seedlings were sprayed with a range of herbicides at the 3-4 trifoliate leaf stage. The herbicides (Table 4) were applied at 90 percent of the lowest recommended rate through a TeeJet flat fan nozzle at a pressure of 200 kPa providing a water volume of 100 L/ha. Shoot weight (gDM/pot) was determined 30 days after the herbicide application. Of the 18 herbicides used, only Broadstrike? and Spinnaker? were considered safe to use on SA 5045. The remaining herbicides caused significant but varying levels of damage to SA 5045. Herald was tolerant of

Broadstrike?, Spinnaker?, Brodal? and Simazine?. The remaining herbicides caused significant levels of damage to Herald (Table 4).

Table 4. Description of selected herbicide treatments (10 of 18) and their effect on shoot weight (expressed as % of unsprayed control) of *T. balansae* (SA 5045) and *M. littoralis* (cv. Herald), LSD (5%) = 36

Trade name	Chemical	Rate applied	SA 5045	Herald
Broadstrike	Flumetsulam (800 g/kg)	25 g/ha	80	93
Spinnaker	Imazethapyr (240 g/L)	0.2 L/ha	82	86
Diurex	Diuron (900 g/kg)	450 g/ha	64	28
Tough	Pyridate (450 g/L)	2 L/ha	55	54
Simazine	Simazine (500 g/L)	1 L/ha	54	80
Brodal	Diflufenican (500 g/L)	0.18 L/ha	46	95
Eclipse	Metosulam (714 g/kg)	6 g/ha	27	22
Igran	Terbutryn (500 g/L)	0.5 L/ha	26	20
MCPA	MCPA (500 g/L)	1 L/ha	15	25
Trifolamine	2,4-DB (400 g/L)	2 L/ha	1	45

In general, *T. balansae* (SA 5045) does not appear to be as tolerant as Herald of broadleaf weed herbicides.

CONCLUSION

Field experiments show that the species *T. balansae* is well adapted to the general soil types where the annual medic species *M. littoralis* and *M. truncatula* are grown in south-eastern Australia. Its general growth, dry matter production and seed yields have been comparable to those of medic and importantly it is compatible with the background populations of *R.. meliloti* associated with medic pastures. This combined with its ease of seed harvest (3) suggest *T. balansae* has the potential to complement the role of annual medics in alkaline soil farming systems. However several key issues will require further investigation before its role can be more clearly defined. These include its ability to compete in mixed pasture swards, its grazing tolerance, its lesser tolerance of herbicides, its ability to host cereal root diseases such as Root Lesion Nematode (*Pratylenchus* spp.), hardseed breakdown patterns and its potential to taint meat or dairy products.

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