Trifolium spumosum L. an exciting prospective legume for fine textured soils in Mediterranean farming systems

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Abstract

Farming systems in southern Australia have and will continue to evolve in response to changing economic and biological pressures. Ley- farming on fine textured soils in southern Australia has been largely based upon annual medics. The sustainability of this system has been challenged:, the high intensity management needed and restrictions associated with seed production and subsequent availability have impacted on the use of annual medics. Consequently alternate species are being developed for this niche. We believe that Trifolium spumosum L. (Bladder clover) has traits that indicate potential for development into a commercial pasture legume. Our research has shown bladder clover to be a highly productive species on mildly acid loams and clay soils. Seed and biological yield in ungrazed swards of bladder clover were equivalent or better than current pasture options on this soil type. In addition to the yield capacity, perhaps the most exciting attribute of bladder clover is the simplicity of harvest using conventional crop machinery. Other important attributes include the hard seed content and breakdown patterns both of which are highly desirable and indicate promise for both ley rotations and phase systems. In terms of long-term persistence, and perhaps one of the most important attributes of bladder clover, is its demonstrated capacity to avoid massive losses of germinating seedlings following out of season rainfall or false breaks in low rainfall environments, which is an issue that compromises subterranean clover

Key words

Hardseededness, seed production, seed size, pasture legumes

Introduction

The traditional ley-farming system that was once so successful in southern Australia is currently challenged in terms of profitability and sustainability. Excessive dependence on herbicides, inefficient use of soil water and nutrients, new pests and diseases, the use of a very narrow suite of legume species and the tendency to manage these as monocultures are examples of the limitations of the traditional farming systems (1). *Trifolium subterraneum* and annual *Medicago* species have been the dominant pasture legumes in these farming systems, however the increased sensitivity to both economic and environmental aspects associated with suction harvesting of seed have made them a less desirable option.

In predicting emerging limitations with current species such as subterranean clover and the annual medics, pasture scientists focussed development activity on a new generation of annual pasture legumes. Many new species have been released to the Australian market with the inception of the Centre for Legumes in Mediterranean Agriculture (CLIMA) in 1992. Species with improved agronomic traits such as a deeper root system, improved persistence, more favourable hard seed breakdown patterns, improved tolerance to pests and diseases and ease of harvest with conventional cereal harvesters were sought.

With the new research focus, several varieties of new species such as biserrula (*Biserrula pelecinus*), French serradella (*Ornithopus sativus*), gland clover (*Trifolium glanduliferum*) and improved varieties of balansa clover (*Trifolium michelianum*) and yellow serradella (*Ornithopus compressus*) have been commercialised. In less than one decade the release of these cultivars has had a strong positive impact on profitability and sustainability of southern Australian farming systems, particularly on sandy textured soils. We believe that *Trifolium spumosum* L. (Bladder clover) has displayed traits that suit it for development as a pasture legume species for fine textured soils. Our research has shown bladder clover to be a highly productive species on acid loams and clays both in dry matter and seed yield capacity. In addition to the yield capacity, perhaps the most exciting attribute of bladder clover is the simplicity of harvest using conventional crop machinery?(4).

In this paper we highlight some of the favourable agronomic characteristics of *T. spumosum* compared to a range of other annual pasture legumes, and conclude these attributes indicate its suitability for emerging farming systems in Mediterranean southern Australia.

Methods

Site details

The field investigation was conducted at Cunderdin (150 km east of Perth), a site with a typical Mediterranean climate, and where traditionally annual medics are well adapted. The soil is fine textured, with a pH (H2O) of 6.2. The average annual rainfall is 400 mm. The experiment was sown on the 29th of May 1998.

Germplasm

Four genotypes of *T. spumosum (M1, M2, M3 and M4)*, selected from germplasm collected in the Mediterranean area (3), were sown with 6 other pasture legumes as controls. The genotypes and sowing rates were as follows: 7 kg/ha for Casbah (*B. pelecinus* L), Prima (*T. glanduliferum* Boiss.) and Frontier (*T. michelianum* Savi); 10 kg/ha for the four genotypes of *T. spumosum* L., Herald (*M. littoralis* Rhode), and Santiago (*M. polymorpha* L.) medic, and 15 kg/ha for Dalkeith (*T. subterranean* L.) subterranean clover.

Experimental design

Plots were 10 by 2.0 m with a 1.2 m buffer between plots, arranged in a randomized block design with three replicates. The site was fertilised with 200 Kg/ha of superphosphate and 70 Kg/ha of muriate of potash. The plots were not grazed, and the herbage was measured in spring at full flower. Available dry matter was estimated from material cut with knives from two randomly placed open quadrats (0.1 m^2) in each plot and dried at 60?C. Two samples (0.1m^2) of mature pods per plot were harvested and threshed to assess seed yield. At the end of summer and in late autumn in 1999 the number of regenerating seedlings were counted in three quadrats of 0.05 m^2 placed randomly in each plot. The plots were sprayed with glyphosate in late autumn 1999 and the entire site was cropped with wheat. The site was let to regenerate in year 2000 with regeneration counts sampled during the year.

Hard seed studies

Samples of mature pods from the site were transferred to the University of Western Australia Field Station at Shenton Park in Perth in December 1998 to measure the rate of seed softening. Samples (each of 100 seeds) of all species were placed in flywire envelopes and laid on the soil surface at the beginning of summer (January) as described by (2). A sample was tested monthly. Six replicate pockets for each accession were removed from the soil surface for the initial and final testings (Jan. and July), and four replicates per accession were sampled for each of the remaining months (Feb. to June). The seeds from each replicate were placed on moistened filter paper in Petri dishes for 14 days at a constant 20?C, and the residual hardseed was recorded.

Results

Yield capacity

T.spumosum was shown to be a highly productive pasture legume compared to those species traditionally used, and the more recent options available for fine textured soils. Dry matter production in ungrazed first year swards ranged between 3.9-5.2 t/ha and slightly improved in the third year (4.1-6.7 t/ha) compared to the controls (Table 1.). Seed yield compared favourably to the highly productive controls (*B. pelecinus* and *M. polymorpha*), ranging from 0.4 to 1.2 t/ha.

Regeneration capacity

In April 1999, after an early rain, the average number of regenerating seedlings of *T.spumosum* was approximately 200/m^2, substantially less than *T.glanduliferum*, *M.littoralis* and *T.subterranean*, which averaged almost 3000 plants/m^2. Two months later (normal break) a new regeneration occurred for the four genotypes of *T.spumosum*, ranging between 800-1600 plants/m^2. After the crop year (year 3 of this experiment) the four genotypes of *T.spumosum* avoided a false break in February 2000 and produced an average of 400 plants/m^2 when winter rainfall commenced in May of that year.

Table 1: Dry matter production (DM), seed yield (SY) and regeneration of 4 genotypes of *T. spumosum* and several annual pasture legumes over 3 years of the experiment (standard errors in brackets).

Legume species	DM	SY	Regeneration		Regeneration		DM
	9/98	11/98	4/99	6/99	2/00	5/00	9/00
	t/ha	t/ha	plant/m^2	plant/m^2	Plant/m^2	Plant/m^2	t/ha
T. spumosum M1	4.5(0.1)	0.9(0.1)	317(73)	1146(448)	50(29)	439(158)	5.6(0.1)
T. spumosum M2	4.6(0.8)	0.6(0.1)	263(142)	1675(650)	42(25)	486(209)	4.7(0.3)
T. spumosum M3	5.2(0.2)	1.2(0.2)	163(19)	771(144)	125(44)	553(265)	6.7(0.3)
T. spumosum M4	3.9(0.4)	0.4(0.1)	154(77)	867(240)	31(11)	250(125)	4.1(0.4)
M. polymorpha Santiago	5.8(0.5)	0.5(0.3)	300(53)	579(151)	172(54)	272(126)	4.9(0.5)
M. littoralis Herald	6.3(0.4)	0.4(0.1)	2933(472)	1946(490)	297(81)	406(64)	5.1(0.4)
B. pelecinus Casbah	4.3(0.3)	0.5(0.1)	0	500(196)	419(161)	333(47)	5.5(0.7)
T. glanduliferum Prima	4.9(0.5)	0.4(0.1)	3550(593)	2325(344)	0	53(14)	2.2(0.9)
T. subterraneum Dalkeith	4.0(0.05)	0.2(0.0)	3225(503)	2475(135)	233(32)	219(22)	3.7(0.5)
T. michelianum Frontier	5.1(0.4)	0.2(0.0)	967(270)	1942(509)	0	56(36)	0

Hard seed breakdown patterns

Hardseeded breakdown rates and final hardseed levels varied within the genotypes of *T. spumosum* and between the species used as controls (Table 2). There was little difference in initial hard seed (January 1999- average 97%). By February both *T. subterranean* and *T. michelianum* had rapidly softened (46 and 37% hardseed left respectively). *T. glanduliferum* began to soften in March, with 58% hardseed at this sample time (Table 2). The hardseeded breakdown of the four genotypes of *T. spumosum* occurred in conjunction with *M. polymorpha*, and the levels of hardseed remaining ranged between 55 to 72% (Table 2). Final levels of hardseed remaining in July were very low for *T. subterranean* and *T. michelianeum* (14 and 4% respectively), compared with 41% for *T. glanduliferum* and between 55 and 77% for the other treatments.

Table 2: Individual seed weight and level of hard-seed of the species tested, during summer on the soil surface. Standard errors are in brackets.

Legume species	**Seed weight mg**	**Hardseed (%)**						
		Jan 99	**Feb99**	**Mar99**	**Apr99**	**May99**	**Jun99**	**July99**
T. spumosum M1	1.9	97 (0.6)	97 (1.0)	84 (1.0)	82 (2.0)	73 (0.5)	73 (6.0)	72 (5.0)
T. spumosum M2	2.1	98 (0.9)	91 (8.0)	90 (5.0)	80 (2.0)	62 (2.0)	58 (4.5)	63 (0.5)
T. spumosum M3	2.6	97 (0.5)	85 (0.5)	87 (3.5)	81 (1.5)	64 (3.5)	60 (10.6)	56 (3.5)
T. spumosum M4	2.4	95 (0.9)	86 (3.0)	87 (5.0)	75 (9.0)	53 (2.5)	57 (8.0)	55 (1.4)
M. polymorpha Santiago	3.6	98 (0.1)	81 (2.0)	80 (0.5)	75 (5.0)	62 (3.0)	61 (2.0)	61 (5.6)
M. littoralis Herald	2.3	95 (3.6)	87 (2.0)	84 (1.0)	84 (0.1)	81 (9.0)	74 (14.0)	77 (11.6)
B. pelecinus Casbah	1.2	99 (0.2)	94 (5.0)	94 (4.0)	82 (12.0)	85 (4.4)	81 (1.0)	76 (3.5)
T. glanduliferum Prima	0.7	98 (0.4)	91 (3.0)	58 (11.6)	60 (5.8)	53 (7.6)	46 (1.0)	41 (8.6)
T. subterraneum Dalkeith	6.7	88 (5.0)	46 (2.0)	36 (0.0)	18 (1.0)	16 (3.5)	16 (5.1)	14 (2.9)
T. michelianum Frontier	0.7	86 (7.7)	37 (7.0)	28 (7.5)	15 (6.0)	9 (3.0)	4 (2.5)	4 (1.3)

Discussion

Seed production and biological yield in ungrazed swards of bladder clover were equivalent or better than current pasture options on this soil type. Secondly, the hard seed content and breakdown patterns were highly desirable and indicate promise for ley rotations. In terms of long-term persistence, and perhaps one of the most important attributes of bladder clover, the demonstrated capacity of bladder clover to avoid massive losses of germinating seedlings is particularly noteworthy

We contend these traits and supporting observations (Table 3) from an extensive collection undertaken in the Greek Islands indicate *T.spumosum* is likely to be well adapted to fine textured soils (sandy loam to heavy clay) in southern Australia. Of specific interest are the moderately acidic to slightly alkaline soils that have historically supported annual medics in this region.

Table 3: Data of over 70 (out of a total of 131) collection-sites in the Greek islands where *T. spumosum* occurred (modified from Nutt *et al*. 1995).

Species	Altitude (m a.s.l.)	Rainfall (mm)	Parent rock*	Soil type*	pH range (CSIRO kit)	Flowering time Range
T. spumosum	0-500	350-800	S, V, G	L, LS, SL C, CL	6.0 -9.5	113-130

* S: schist, V: volcanic, G: granitic
** L: loam, LS: loamy-sand, SL: sandy loam, C: clay, CL: Clay-loam

Annual medics have proven to be well adapted to fine textured soils under a traditional ley farming system and can be highly productive. Their continued suitability is however limited, given soil acidification, intensive management demands (e.g. control of pests and diseases, careful summer grazing) and seed production technology. Our results indicate that *T. spumosum* has the potential to satisfy this niche in southern Australian farming systems, perhaps in mixtures with annual medics. Bladder clover is highly productive with reported yields of 15 tonnes of dry matter per hectare in high rainfall environments (Nutt personal communication). The prolific seed yield capacity (with seed yields up to 1200 kg/ha) and simplicity of harvest with cereal headers is an exciting attribute. *T spumosum* is readily harvestable and easy to process (4), and has a harvestability index (HI) of 74% compared to another aerial clover *T. hirtum* (rose clover 49%). This is a clear advantage over subterranean clover and annual medics, which require expensive, time consuming and environmentally damaging suction harvesting to produce seed.

When considering long-term persistence, the hard seed content of bladder clover is encouraging. During the three-year term of the experiment described here, the site was subjected to severe false breaks (unseasonal rainfall) in 2 of the 3 years. Out of season rainfall severely impacted on establishment of *T. subterraneum* and *T. michelanium:*, in contrast *T. spumosum* appeared to be protected from false breaks, and was able to establish satisfactorily each year. Our results show that the hard seed breakdown of *T. spumosum* occurred at the end of summer, compared to *T. subterraneum* and *T. michelianum*, which had 50% germinable seed by early summer (February). The final level of hardseed (55 to 72%) in the accessions of *T. spumosum* assessed together with regeneration data from the field suggests that the species has adequate hardseed to survive a crop rotation but is also suitable for use in a phase farming system.

References

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