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Potential new alternative annual pasture legumes for Australian Mediterranean farming system

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Summary - The southern Australian Mediterranean agricultural systems depend heavily on annual pasture legumes grown in rotation with cereals. Subterranean clover and annual medics have been the dominant species, however their performances have not always been reliable because of the great variation in soil, climatic characteristics and new intensive cropping regimes. In this paper we discuss some of the agronomic traits of new alternative pasture legumes with potential for the southern Australian systems.

Key words: pasture legumes, seed yield, dry matter production, hardseededness

***Résumé* -** Les systemes agricoles de l'Australie du Sud sont strictement conditionnés par les legumineuses annuelles à pâturages cultivées en rotation avec les céréales. Le trefle souterain et les médics annuelles ont été les espèces dominantes,en tout cas leurs productions n'ont pas toujours été sûres à cause des variations remarquables des sols, des caractéristiques climatiques et des nouveaux systemes culturaux intensifs. Dans cette recherche on expose certaines caractéristiques agronomiques des nouvelles légumineuses alternatives à pâturage qui peuvent être importantes pour les systèmes agricoles de l'Australie du Sud.

Mots-clés: pâturage légumineuse, production de matière seche, production de graines

Introduction

Exotic pasture plants of Mediterranean origin have become the central component of pasture systems in southern Australia. The key to success of these systems has been the planned introduction of a legume component, mostly subterranean clover (*Trifolium subterraneum* L.) and annual medic (*Medicago* spp.). In many regions a system has evolved where legume-based pastures are grown rotationally with crops. An important feature of these rotations is the ability of the sown pasture legume to spontaneously regenerate in the year following the crop. The legume-based pasture provides a source of forage for livestock and confers benefits such as symbiotically fixed nitrogen which becomes available to subsequent crops.

Technological and economic changes have lead to new systems which often involve longer sequences of crop, usually including grain legumes and oil seeds along with the traditionally used cereals. The seed reserves of the sown pasture legumes are exhausted during these extended periods of crop and spontaneous regeneration is no longer so common. This requires reintroduction of a pasture legume at the start of each pasture phase (Reeve and Ewing 1993). The emergence of a new system (phase farming system) creates the opportunity to use a wide range of annual pasture legumes with different characteristics. Plant traits which confer ease of seed production leading to low seed production cost will be important in new species because of the need for regular re-sowing of phase pastures. Also lower levels of hard seed will be desirable because of the reduced importance of establishing a reserve of seeds to provide a regenerating population following a cropping phase.

The experiments outlined were undertaken with representative cultivars of a number of annual Mediterranean legumes to make a preliminary evaluation of their suitability for new farming systems for southern Australia. While high dry matter and seed production potential remain important traits of pasture legumes for all farming systems, seed germination characteristics will be central in determining ability to persist in contrasting rotational scenarios.

Materials and methods

The field investigation was conducted at Mingenew (400 km north-east of Perth, WA) and Cunderdin (150 km east of Perth), on sites where traditionally annual medics are well adapted. The soil at both sites is fine textured, with pH (H_2O) of 5.8 and 6.2 respectively. The average annual rainfall is 400 mm for both sites. The experiments were sown on the 19th of May 1998 at Mingenew and on the 29th of May 1998 at Cunderdin. Fifteen annual pasture species were used in the experiments. The genotypes and sowing rates were: 7 Kg ha^{-1} for Casbah (*Biserrula pelecinus* L.), 10 Kg ha^{-1} for *Hymenocarpus circinnatus* (L.) Savi, Herald (*Medicago littoralis* Rhode), Santiago (*Medicago polymorpha* L.), Calyph (*Medicago truncatula* Gaetrn.), Santorini (*Ornithopus compressus* L.), *Scorpiurus vermiculatus* L., *Trifolium formosum* Urv., *Trifolium glanduliferum* Boiss., Frontier (*Trifolium michelianum* Savi), *Trifolium spumosum* L., and *Trigonella balansae*, 15 Kg ha^{-1} for Dalkeith (*Trifolium subterraneum* L.) and *Trifolium clypeatum* L., 20 Kg ha^{-1} of pods for Cadiz (*Ornithopus sativus* Brot.). Plots were 10 by 2.0 m with 1.2 m between plots, arranged in a spatially randomized block design with three replicates.

The sites were fertilised with 200 Kg ha^{-1} of superphosphate and 70 Kg ha^{-1} of murate of potash. Plots were not grazed, and the herbage was measured in spring at full flower. Two samples (0.1m^2) of mature pods per plot were harvested and threshed to assess seed yield.

Additional mature pods of all species were harvested at Cunderdin and tested at Shenton Park Field Station in Perth for their levels of hardseed. Six 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 Loi *et al.*, 1999. The pods were sampled at 0 (January), 90 (April) and 180 days (July) and the percentage of hard seed was recorded.

Results and discussion

Dry matter production and seed yield of the 15 species evaluated is reported in Table 1. The dry matter production of the three species of annual medics was high (ranging from 3.8 to 6.5 t ha^{-1} for dry matter and 379 to 665 Kg ha^{-1} for seed yield). However a number of other species produced high dry matter production, particularly at the more acid Mingenew site where production of *B. pelecinus*, *Ornithopus* spp., *T. michelianum* and *T. spumosum* were similar to the annual medic controls. *T. spumosum* showed a clear seed production superiority over all other species at both test sites (1058 to 1297 Kg ha^{-1}). Although the annual medics produced more seed than most other species, *B. pelecinus, T. glanduliferum, T. michelianum* and *T. balansae* produced such a large number of seeds (individual seed weight: 0.7 to 1.3 mg) (Table 2), which correspond to almost 1500 Kg ha^{-1} of medics and 3000 Kg ha^{-1} of *T. subterraneum.*

Table 1. Dry matter production (t ha^{-1}) and seed yield (kg ha $^{-1}$) and standard errors of several annual pasture legumes at two sites in Western Australia

Legume species	Dry matter				Seed yield			
	Cunderdin		Mingenew		Cunderdin		Mingenew	
	t ha^{-1}	SE	t ha^{-1}	SE	Kg ha^{-1}	SE	Kg ha^{-1}	SE
B. pelecinus cv Casbah	4.3	0.3	4.9	1.3	439	148	568	224
H. circinnatus	2.2	0.2	4.0	0.1	182	112	243	46
M. littoralis cv. Herald	6.3	0.4	5.6	0.9	379	95	607	178
M. polymorpha cv. Santiago	5.8	0.5	4.9	0.2	502	335	665	109
M. truncatula cv. Calyph	6.5	0.2	3.8	0.5	648	121	582	62
O. compressus cv. Santorini	3.1	0.5	5.2	0.9	801*	138	676*	118
O. sativus cv. Cadiz	4.3	0.6	5.8	0.3	357*	147	38*	20
S. vermiculatus	3.5	0.4	3.5	0.2	154	34	37	27
T. clypeatum	3.8	0.7	3.2	0.4	407	205	204	60
T. formosum	5.6	1.3	4.1	0.7	663	191	310	5
T. glanduliferum	4.9	0.5	4.1	0.3	367	125	427	145
T. michelianum cv. Frontier	5.1	0.4	5.1	0.7	237	47	168	43
T. spumosum	5.3	0.8	5.1	0.9	1297	186	1058	55
T. subterraneum cv. Dalkeith	4.0	0.05	4.6	0.1	201	36	252	40
Trigonella balansae	4.7	0.4	3.8	0.1	623	157	547	36

* Pods

Table 2. Individual seed weight (mg), and levels of hardseededness (%) of the species evaluated at Cunderdin

Legume species	Seed weight	Hard seed levels					
		Initial (0 days)		Mid autumn (90 days)		Final (180 days)	
	(mg)	%	SE	%	SE	%	SE
B. pelecinus cv Casbah	1.2	99	0.2	90	4.5	86	5.4
H. circinnatus	6.2	100	0.2	88	2.5	16	1.9
M. littoralis cv. Herald	2.3	95	3.6	90	1.0	85	3.8
M. polymorpha cv. Santiago	3.6	69	4.0	75	5.1	61	5.6
M. truncatula cv. Calyph	3.7	98	2.0	88	2.5	82	2.9
O. compressus cv. Santorini	3.2	99	0.3	94	1.5	78	3.6
O. sativus cv. Cadiz	2.5	0	0	n.t.	n.t.	0	0
S. vermiculatus	15.5	92	2.9	31	0.5	34	4.7
T. clypeatum	8.6	94	0.4	67	0.5	40	4.0
T. formosum	6.2	89	1.3	82	2.0	67	3.0
T. glanduliferum	0.7	98	0.5	60	5.6	56	3.6
T. michelianum cv. Frontier	0.7	86	7.7	15	6.1	4	1.3
T. spumosum	2.6	97	0.5	81	1.5	57	1.7
T. subterraneum cv. Dalkeith	6.7	79	1.9	18	1.0	14	3.0
Trigonella balansae	1.3	95	1.1	40	5.6	17	2.2

n.t. not tested

The variation in percentage of hard seed is reported in Table 2. The level of initial hard seed was generally high for all plants tested except *O. sativus* which was fully germinable at the initial test time. Species differed in the progress of softening during the summer period. Some like *T. subterraneum,* S. *vermiculatus, T. michelianum, T. balansae and T. glanduliferum* had reached the maximum germinability at the mid-autumn sampling time. While others (*H. circinnatus, T. formosum and T. spumosum)* softened substantially in the second 90 days period (Table 2). *B. pelecinus, O. compressus* and the two annual medics Herald and Calyph remained very hard (average 83%) throughout autumn.

Conclusion

Annual medics are well adapted to fine textured soils and can be highly productive. However, strict soil type preferences, intensive seed production systems and the intensive management required (e.g. control of pest and diseases, careful summer grazing) are deterrents to adoption under prevailing economic conditions. Potential alternative species used in the experiment are easily harvested and threshed. In particular *O. sativus, T. glanduliferum, T. spumosum, T. formosum* and *T. balansae* can be harvested using machines freely available to farmers (such as conventional cereal harvesters) instead of the specialist and environmentally damaging suction harvester used for subterranean clover and the annual medics (Nutt and Loi, 1999).

In some species tested the hardseed breakdown occurs during late summer or autumn and they are therefore protected from "false breaks" (germinating after unseasonal rains) which otherwise result in seedling death. Furthermore the high levels of hard seed suggest that *B. pelecinus* and *O. compressus* are better suited to ley farming, whilst *O. sativus, T. glanduliferum, T. spumosum, T. formosum* and *T. balansae* are likely to be suited to phase farming. Finally, high grazing pressures and poor grazing management are the major causes of the seed bank impoverishment of medics. Species such *B. pelecinus, T. glanduliferum, T. spumosum and T. michelianum* are more likely to survive ingestion by sheep during summer because of their small seeds compared to medics and subterranean clover.

Further experiments to investigate the persistence and the management of these new alternative species are currently underway. When complete, we will be in a position to recommend the adoption of appropriate species and varieties for a range of crop:pasture farming systems.

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