New pasture legumes for the grainbelt

Phillip Nichols[1,2] and Bradley Wintle[1], [1]DAFWA South Perth, [2]UWA School of Agriculture and Environment

Key messages

Tammin® and Forbes® are new early flowering sub clovers with greater hardseededness than older cultivars and seedling resistance to redlegged earth mites. Tammin® is suited to areas with 300-450mm annual average rainfall (AAR) and is available in 2017, while Forbes® is suited to areas with 350-525mm AAR and will be available in 2019.

Rouse® and Yanco® are new highly productive, waterlogging-tolerant sub clover cultivars of the *yanninicum* subspecies of sub clover. Rouse® is suited to areas with 550-900mm AAR and seed is available in 2017, while Yanco® is suited to 450-700mm AAR and will be available in 2018.

Messina is a new annual pasture legume suited to saline, waterlogged areas unsuited to cropping. It requires inoculation with a specially developed salt-tolerant *Rhizobium* strain. Seed of a new cultivar, to be launched in March 2017, and the new *Rhizobium* will be available for 2017 sowing in areas with ≥ 375 mm AAR and topsoil $pH_{(Ca)}$ ≥5.5.

Aims

This paper describes research leading to the release of four new subterranean (sub) clover cultivars bred by DAFWA and the first cultivar of messina (*Melilotus siculus*), a new annual pasture legume suited to saline, waterlogged soils.

New sub clover cultivars

Tammin® and Forbes® - early flowering, hardseeded sub clovers with RLEM cotyledon resistance

Tammin® and Forbes® are new early flowering sub clovers with greater hardseededness than other sub clovers and seedling (cotyledon) resistance to redlegged earth mite (RLEM). Both are derived from a complex cross involving cv Dalkeith, three naturalised WA strains and a wild plant collected in Sicily. Attributes of Tammin®, Forbes® and other early flowering cultivars are shown in Table 1. Time to first flowering, levels of the oestrogenic compound, formononetin, and the softening of hard seeds were measured in Perth from irrigated rows sown on 10 May, 2012 (mean of three replicates). Hard seed softening was tracked using freshly harvested seeds (100 x three replicates x eight sampling times) placed on the soil surface and collected every 28 days until 24 May 2013 and germinated in Petri dishes. Additional samples were tested in mid-June of the following three years. RLEM damage was measured in the glasshouse as the per cent of cotyledon silvering, following application of RLEM to 7-day old seedlings (four replicates). Reaction to clover scorch disease (*Kabatiella caulivora*) was measured by M.J. Barbetti and M.P. You (UWA) following inoculation of irrigated rows (two replicates) at Medina in 2011 with a mixture of Races 1 and 2.

Tammin® flowers 88 days after sowing in Perth (8 days earlier than Dalkeith) and is suited to 300-450mm AAR areas, while Forbes® flowers after 101 days and is suited to 350-525mm AAR areas. Both have trace formononetin levels and will not cause ewe infertility problems. They are highly susceptible to clover scorch, but this disease has little impact in low rainfall areas. Tammin® had 51.3% and Forbes® had 32.7% of seeds still hard in the May following seed set, compared with 16.3% for Dalkeith and ≤24% for all other cultivars, (Table 1), resulting in a higher proportion of seeds for regeneration following a year in crop. After two summer-autumn periods Tammin® still had 19.3% and Forbes® had 9.3% of hard seeds, while all other cultivars had ≤2%, and after four summer-autumn periods Tammin® had 7.7% of seeds still hard (Figure 1). Their higher hardseededness indicates Tammin® and Forbes® are better suited to crop rotations than other sub clovers.

Table 1. Key varietal characteristics of Tammin®, Forbes® and other early flowering sub clover cultivars.

Cultivar	Hardseededness (% hard seeds after summer-autumn)	Flowering time (days from early May sowing in Perth)	RLEM damage (% cotyledon silvering)	Formononetin (% of dry matter)	Clover scorch (HR = highly resistant HS = highly susceptible)
Tammin®	51.3	88	6.1	0.00	HS
Forbes®	32.7	101	6.0	0.00	HS
Urana®	24.3	105	25.4	0.00	HS
Nungarin	23.7	77	32.9	0.05	HS
Izmir®	21.7	80	27.9	0.05	HS
Geraldton	17.3	88	40.8	1.10	HS
Dalkeith	16.3	96	39.2	0.00	HS
Losa®	9.3	95	28.3	0.05	HS
Lsd (P=0.05)	5.2	2.1	6.3	0.04	

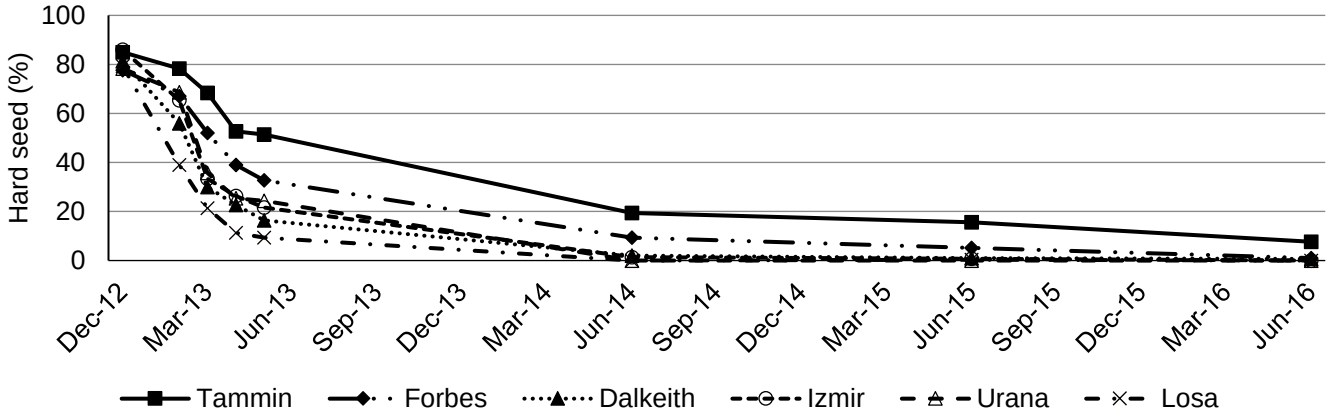

Figure 1. Softening of hard seeds over four summer-autumn periods on the soil surface at South Perth of Tammin, Forbes and other early flowering cultivars.

Tammin and Forbes were the most productive and persistent of 18 breeding lines and six cultivars over three seasons at Tammin and Katanning (two trials) and two sites in Victoria and NSW. Across all sites and seasons total biomass production of Tammin and Forbes was 11-12% more than Dalkeith, 46-47% more than Geraldton, 29-30% more than Nungarin, 17-18% more than Izmir and 15-16% more than both Losa and Urana (Figure 2).

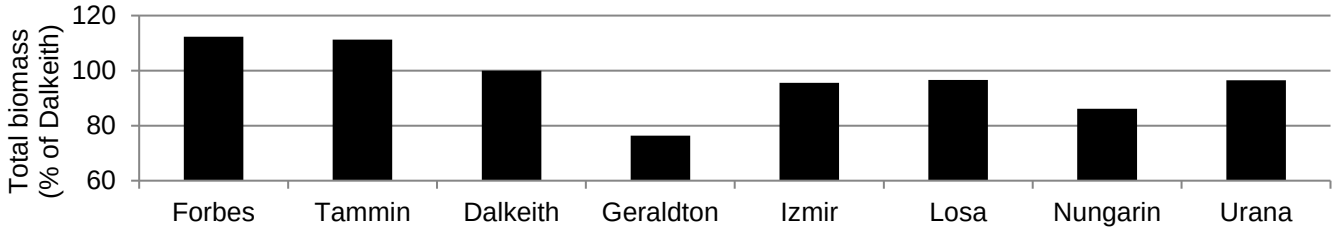

Figure 2. Total clover biomass across six sites and three seasons of Tammin, Forbes and other early flowering cultivars, expressed as a per cent of cv Dalkeith.

The advantage of the high hardseededness of cvs Tammin and Forbes was apparent at Tammin and one of the Katanning sites, which were cropped in the year after sowing. Across both sites, Tammin produced 56% more spring biomass and Forbes produced 96% more than cv Dalkeith in the year after cropping (Figure 3).

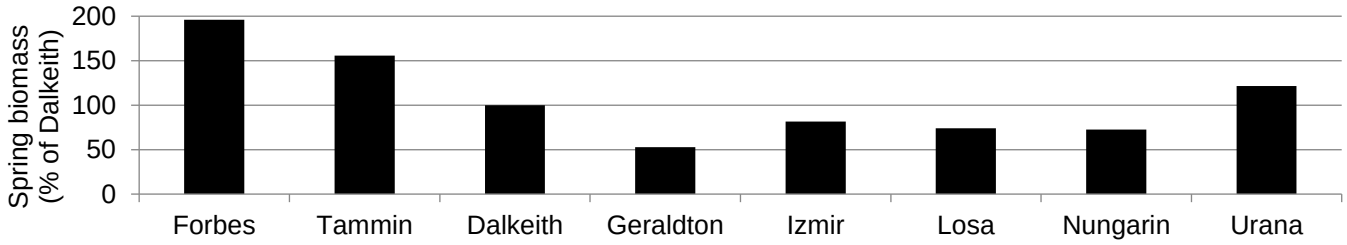

Figure 3. Spring biomass of Tammin, Forbes and other early flowering cultivars in the year following a crop at Tammin and Katanning, expressed as a per cent of cv Dalkeith.

Rouse and Yanco – sub clovers for high rainfall, waterlogged soils

Rouse and Yanco are new highly productive cultivars of the waterlogging-tolerant, "white-seeded" *yanninicum* subspecies of sub clover, suited to mixed farming and permanent pastures in higher rainfall grainbelt regions. Yanco originates from a cross between cv Gosse and a wild plant collected in Turkey, while Rouse is derived from a cross between cv Riverina and a plant collected in Greece. Attributes of Rouse, Yanco and other ssp. *yanninicum* cultivars are shown in Table 2. Measurements were conducted in 2012 using the methods described for Tammin and Forbes. Yanco flowers 121 days from an early May sowing in Perth and is suited to areas with 450-700mm AAR, while Rouse flowers after 131 days and is suited to 550-900mm AAR areas. Both have formononetin levels <0.2% of dry matter (DM) and will not cause ewe infertility and lambing problems. Rouse and Yanco have high resistance to Races 1 and 2 of clover scorch disease, but have similar RLEM susceptibly to other cultivars. Both are soft-seeded, but should persist in crop rotations, provided crop frequency is not greater than one year in three.

Table 2. Key varietal characteristics of Yanco, Rouse and other ssp. *yanninicum* sub clover cultivars.

Cultivar	Flowering time (days from early May sowing in Perth)	Formononetin (% of dry matter)	Kabatiella (HR = highly resistant HS = highly susceptible)	RLEM cotyledon resistance	Hardseededness (1 = very soft 10 = very hard)
Yanco®	121	0.15	HR	S	2.5
Rouse®	131	0.10	HR	S	1.5
Gosse	128	0.10	R	S	1.5
Riverina	122	0.10	MR	S	1.5
Trikkala	117	0.10	MR	S	1
Monti®	115	0.10	R	S	1.5
Napier®	140	0.10	R	S	2.5
Lsd (P=0.05)	1.8	0.04			

Rouse® and Yanco® were the most productive and persistent of 13 breeding lines and five cultivars over three seasons in replicated trials at Mt Barker and Manjimup and two sites in Victoria. Across all sites and years Rouse® produced 46% more biomass than cv Riverina, 33% more than cv Monti®, 29% more than cvs Gosse and Trikkala, and 25% more than cv Napier®, while Yanco® produced 27% more biomass than Riverina, 17% more than Monti®, 12% more than Gosse and Trikkala, and 9% more than Napier® (Figure 4).

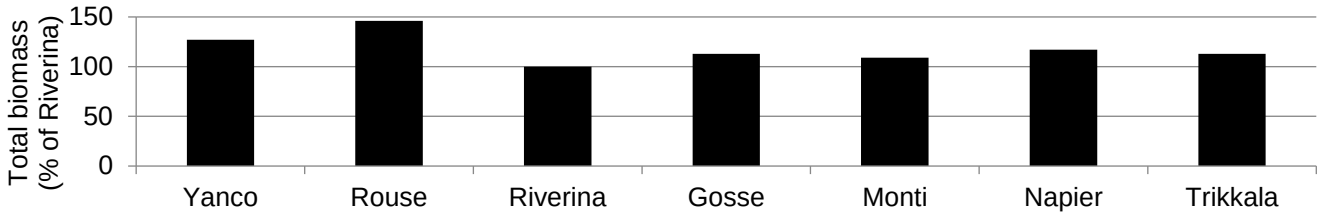

Figure 4. Total biomass across four sites and three seasons of Yanco®, Rouse® and other ssp. *yanninicum* cultivars, expressed as a per cent of cv Riverina.

Messina – a new annual legume for saline, waterlogged soils

Messina is a new annual pasture legume species to world agriculture with tolerance to both severe salinity and winter waterlogging. It has similar waterlogging tolerance to balansa clover, but much higher salt tolerance. A new cultivar, originally collected in Israel and codenamed SA40002, has been selected by DAFWA and SARDI, following work conducted through the former Future Farm Industries CRC (FFI CRC). A salt tolerant 'Special Inoculant' *Rhizobium* strain (SRDI554) has been selected by SARDI for use with messina. SA40002 messina has persisted on soils with EC_e up to 32dS/m in the topsoil over summer-autumn and textures ranging from sands to clays and is suited for sowing in areas with >375mm AAR on soils with $pH_{(Ca)}$ ≥5.5. It will complement salt tolerant perennial grasses, acting as a nitrogen (N) source to increase their productivity, or as an understorey legume in saltbush-based pastures and can be mixed with other annual legumes, such as balansa clover, burr medic and white melilot.

Research to identify annual pasture legumes with salt and waterlogging tolerance commenced in 2003. A total of 33 species were evaluated over three years at seven saline sites across southern Australia. Included among these was messina, a little-known wild species from the Mediterranean basin and surrounding areas. The potential of messina became apparent when it was the only species with regenerating seedlings at two winter waterlogged sites with severe salinity levels (EC_e >30dS/m) in the top 10cm over summer (Nichols et al 2008). However, these seedlings failed to nodulate with the commercial annual medic *Rhizobium* strain. This led to screening of 80 rhizobia strains at saline sites at Darkan, WA and Keith, SA, resulting in selection of strain SRD554 (Bonython et al 2011). This enabled evaluation of messina germplasm, collected from the Mediterranean basin, to proceed.

SA40002 was the most productive and persistent of 21 messina accessions over three years on saline waterlogged soils at Darkan and Tambellup in WA and at three sites in SA. It also produced more biomass than Frontier® balansa clover, Scimitar® burr medic and Jota white melilot, the three best current pasture legumes for saline land. At the two WA sites total DM yield of Frontier®, Scimitar® and Jota over three years was only 17%, 16% and 3%, respectively, of SA40002 messina (Figure 5), which had a highest annual plot DM measurement at Darkan of 7.6t/ha.

Glasshouse studies have confirmed the high tolerances of messina to salinity and waterlogging (Rogers et al 2011; Teakle et al 2012), with growth continuing after 14 days in a 550mM NaCl solution (seawater concentration). Its waterlogging tolerance is conferred by roots with air channels that also produce 'phellem', a white, spongy layer. SA40002 seedlings tolerated 320mM NaCl before suffering germination reductions, compared to 120mM for Frontier® balansa clover (Nichols et al 2009), suggesting a critical electrical conductivity (EC_e) level of ~32dS/m in the field.

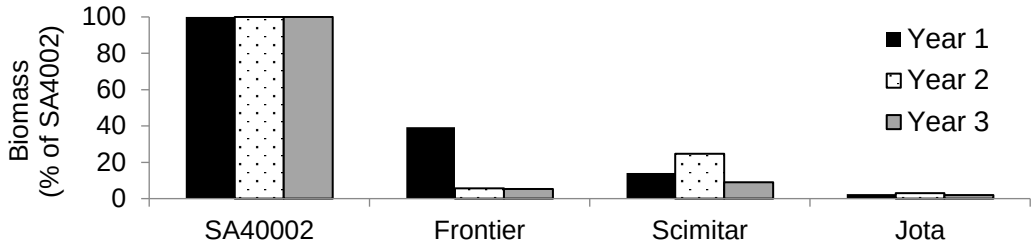

Figure 5. Mean biomass production of SA40002 messina, Frontier balansa clover, Scimitar burr medic and Jota white melilot (as a per cent of SA40002) over three years at saline, waterlogged sites at Darkan and Tambellup, WA.

Flowering time and hard seed softening were measured in Perth from irrigated rows sown on 1 June, 2010 (three replicates). Seed softening was measured every 28 days until 15 June 2011 using the same methods described above. SA40002 commenced flowering 98 days after sowing, compared to 101 days for Frontier, 87 days for Scimitar and 159 days for Jota. In mid-June SA40002 had 26% of its seeds still hard, compared to 5% for Frontier, 9% for Jota and 42% for Scimitar (R. Jeffery and P.G.H. Nichols, unpublished data). This level ensures seed germination in years following little or no seed set, while allowing high seedling germination densities in most years. Few SA40002 seeds softened before mid-March, while ~23% softened between mid-May and mid-June. This acts to defer germination until reliable rainfall, capable of flushing salts from the surface, is more likely to occur.

Fresh growth of SA40002 has high nutritive value, with 82% digestibility, 28% crude protein, 31% neutral detergent fibre and 13MJ/kg DM metabolisable energy and no known toxic chemicals (A.M. Pearce and A.D. Craig, unpublished data). A sheep grazing trial (J. Edwards and E. Babiszewski, unpublished data) showed pure SA40002 poses no threat to livestock health and produces meat acceptable to consumers. However, SA40002 was less palatable than sub clover and lower live weight gains were achieved, while other observations indicate it is readily grazed when other species are also present. SA40002 is, therefore, recommended for use in mixed pastures, although the inherent heterogeneity of most saline paddocks will result in it and other pasture components occupying different niches.

Conclusions

The higher hardseededness and RLEM seedling resistance of Tammin and Forbes make them better adapted than other sub clovers to crop rotations in low and medium rainfall areas, while Rouse and Yanco are more productive waterlogging tolerant cultivars for mixed farming and permanent pastures in high rainfall areas. The new cultivars are estimated to increase the annual value of livestock production by $10-$18/ha and N input by $12-$18/ha over current cultivars. Tammin and Rouse are available for sowing in 2017, Yanco will be available in 2018 and Forbes will be available in 2019. Seed Force (www.seedforce.com.au) has the marketing licence for each cultivar.

Messina offers a new opportunity for increased animal production on unproductive and highly N-deficient saline, waterlogged land unsuited to cropping. This will allow mixed farmers to increase crop area, while maintaining stock numbers. The FFI CRC estimated messina can increase productivity by four dse/ha across 600 000ha of saltland in southern Australia, giving an annual value of $36million for additional livestock production and $16.3million for fixed N. SA40002 messina seed and SRDI554 *Rhizobium* are available for sowing in 2017. Seednet (www.seednet.com.au) has the marketing licence for SA40002, which will be officially launched in March 2017.

Key words

Pasture legumes, subterranean clover, messina, *Melilotus*, cultivars

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Cultivars displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994.