

AGWEST Sothis: *Trifolium dasyurum* (eastern star clover)

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Abstract. *Trifolium dasyurum* C. Presl. (eastern star clover) is a species native to the eastern Mediterranean regions. AGWEST Sothis is the first cultivar of eastern star clover released to world agriculture. It has high levels of dry matter and seed production and seed can be harvested with modified grain harvesters. AGWEST Sothis is suitable for use on acid and alkaline fine-textured soils in low to medium rainfall areas (325–450 mm) in southern Australia. AGWEST Sothis is an early to mid-maturing variety, flowering ~100 days after emergence in Perth, Australia. Individual seeds weigh ~6 mg. In regenerating stands, AGWEST Sothis germinates very late in the season compared with traditional pasture legumes such as subterranean clover (*Trifolium subterraneum* L.) and annual medics (*Medicago* spp.) and weeds. The delay in germination allows the use of non-selective herbicides or intensive grazing after the break of season for a long period 3–6 weeks to obtain >90% control of troublesome crop weeds. In spite of its late germination, AGWEST Sothis grows rapidly in late winter/spring and can become a productive legume-dominant pasture for grazing or forage conservation.

Origin

Trifolium dasyurum C. Presl. (eastern star clover) is classified in the tribe of *Trifolieae*, section *Trifolium*, sub-section *Angustifolia* (Zohary and Heller 1984). *T. dasyurum* is native to the southern Mediterranean areas of Europe (Greece, Aegean islands, Cyprus), Africa (Egypt and Libya) and Middle East (Turkey, Syria, Palestine, Iraq and Iran).

AGWEST Sothis (GCN39) was collected by Mr Brad Nutt and Dr Steve Carr in June 1995 at Naxos Island (Greece) 3 km east of Glanado (37°05'2"N, 25°24'47"E) (Nutt *et al.* 1996). Two plants of *T. dasyurum* were found at the site and two dry heads were collected from each plant. No other populations were found on the island at the time of the collection.

Mr Jeremy Wasley and Mr Brad Nutt first identified *T. dasyurum* as a species with commercial potential within a Grains Research and Development Corporation (GRDC) funded program in 1996 (Nichols *et al.* 2006).

A range of accessions of *T. dasyurum* were grown as spaced plants at Perth, Western Australia, Australia, by Mr Richard Snowball (Australian *Trifolium* Genetic Resource Centre) in 1996 and the accession GCN39 was shown to be very uniform and was selected for its earliness of flowering and winter vigour. Further development and commercialisation of this cultivar as AGWEST Sothis was supported by the National Annual Pasture Legume Improvement Program, funded by GRDC and Australian Wool Innovation, with principal investigators Dr Angelo Loi and Mr Brad Nutt. Intensive hard seed studies were conducted by Dr Loi and Mr Nutt, which lead to the discovery of its particular hard seed breakdown pattern and delayed germination. Subsequent experiments have highlighted the potential benefits this cultivar in providing control of herbicide-resistant weeds in current and emerging Mediterranean farming systems (Loi *et al.* 2006). AGWEST Sothis was released in February 2007 by the Department of Agriculture and Food of Western Australia

(DAFWA), Australia. Pre-basic seed of the variety will be maintained by the Genetic Resource Centre for Temperate Pasture Legumes at DAFWA.

The name Sothis is derived from the ancient Greek name for the star Sirius.

Morphological description

AGWEST Sothis is an annual legume ($2n = 16$), with an erect growth habit, 50–60 cm tall. Stems are striate, ascending, slightly branching, and often terminating in a flower-bearing dichotomium. Leaves (3–4 cm) are petiolate and the uppermost ones subsessile. Leaf markers in AGWEST Sothis are completely absent. Stipules are generally membranous inflates, with arcuate ribs and long, subulate to cuspidate tip. Leaflets are elliptical to oblong, 4–5 × 1–1.5 cm. The heads are 3–4 cm long, many-flowered, ovoid to rhomboid. Calyx are appressed-hirsute, with teeth of equal length, with lanceolate base, almost twice as long as the tube. Corolla is generally purple at tip, whitish or pink at the base, as long as the calyx or shorter. Standard is almost 5 mm and generally is longer than wings. AGWEST Sothis is mostly self-pollinated. Pods are oblong, globular and each containing one seed. Each seed is 1.8 mm long, yellowish in colour, with individual seed weight of 6 mg.

Agronomic performance

AGWEST Sothis is an early to mid-maturing cultivar, flowering ~100 days after emergence from a mid May sowing in Perth, Western Australia (WA; 31°52'48"S, 115°52'58"E), Australia. It is suited to regions with 300 to 500 mm average annual rainfall with a Mediterranean rainfall distribution pattern and can be grown on acidic and alkaline sandy-loam and loamy soils (pH 5 to 8). Seed needs to be inoculated with *Rhizobium leguminosarum* bv. *trifolii* 'Group C' for clovers.

Table 1. Herbage and seed yields (mean \pm s.e.) in the year of establishment (1998) and seed yield at Cunderdin and Mingenew, Western Australia

Species and cultivar	Herbage yield (t/ha)		Seed yield (kg/ha)	
	Cunderdin	Mingenew	Cunderdin	Mingenew
<i>Trifolium dasyurum</i> cv. AGWEST Sothis	5.6 \pm 1.3	4.1 \pm 0.7	663 \pm 191	310 \pm 5
<i>Biserrula pelecinus</i> cv. Casbah	4.3 \pm 0.3	4.9 \pm 1.3	439 \pm 148	568 \pm 224
<i>Medicago littoralis</i> cv. Herald	6.3 \pm 0.4	5.6 \pm 0.9	379 \pm 95	607 \pm 178
<i>Medicago polymorpha</i> cv. Santiago	5.8 \pm 0.5	4.9 \pm 0.2	502 \pm 335	665 \pm 109
<i>Medicago truncatula</i> cv. Caliph	6.5 \pm 0.2	3.8 \pm 0.5	648 \pm 121	582 \pm 62
<i>Ornithopus compressus</i> cv. Santorini ^A	3.1 \pm 0.5	5.2 \pm 0.9	801 \pm 138 ^A	676 \pm 118 ^A
<i>Ornithopus sativus</i> cv. Cadiz	4.3 \pm 0.6	5.8 \pm 0.3	357 \pm 147 ^A	38 \pm 20 ^A
<i>Trifolium glanduliferum</i> cv. Prima	4.9 \pm 0.5	4.1 \pm 0.3	367 \pm 125	427 \pm 145
<i>Trifolium michelianum</i> cv. Frontier	5.1 \pm 0.4	5.1 \pm 0.7	237 \pm 47	168 \pm 43
<i>Trifolium subterraneum</i> cv. Dalkeith	4.0 \pm 0.05	4.6 \pm 0.1	201 \pm 36	252 \pm 40

^APods only.

An agronomic evaluation of eastern star clover and other pasture species was conducted at Mingenew (29°11'S, 115°25'E, ~400 km north-east of Perth), Cunderdin (31°39'S, 117°13'E, ~150 km east of Perth) and Pingelly (32°31'S, 117°05'E, ~140 km south-east of Perth). The three sites have a typical Mediterranean climate, with the Cunderdin and Mingenew sites having a fine textured soil, and pH (H₂O) of 6.2 and 5.8, respectively. Soil at the Pingelly site was an acidic sandy loam with a pH (H₂O) of 5.0. The average annual rainfall for the sites is 365 mm, 370 mm and 440 mm, respectively, with a shorter and warmer growing season at Mingenew site. Dry matter production and seed yield were collected in the first and third years. Regenerating seedling counts were recorded in the second and third year of the trial after the site was cropped.

Herbage production in spring of ungrazed AGWEST Sothis for the first year of establishment ranged from 4.1 to 5.6 t/ha (Table 1). Seed yields ranged from 310 to 663 kg/ha (Table 1). Norman *et al.* (2005) found that AGWEST Sothis was also able to set adequate amounts of seed under moderate grazing. It has high forage quality in terms of dry matter digestibility (71%) and crude protein generally varies between 20 and 25% at the start of flowering (Norman *et al.* 2005).

Mature pods of several species were harvested at Cunderdin and tested at Shenton Park Field Station in Perth for their levels of hard seed. 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),

Table 2. Individual seed weight (mg) and seed softening (percentage hard seed \pm s.e.) of freshly harvested AGWEST Sothis and other annual pasture legumes in the field over summer and autumn at Perth, Western Australia, at 0, 90, and 180 days from 10 January 1999

Species and cultivar	Seed weight (mg)	Hard seed levels		
		0 days	90 days	180 days
<i>Trifolium dasyurum</i> cv. AGWEST Sothis	6.2	89 \pm 1.3	82 \pm 2.0	67 \pm 3.0
<i>Biserrula pelecinus</i> cv. Casbah	1.2	99 \pm 0.2	90 \pm 4.5	86 \pm 5.4
<i>Medicago littoralis</i> cv. Herald	2.3	95 \pm 3.6	90 \pm 1.0	85 \pm 3.8
<i>Medicago polymorpha</i> cv. Santiago	3.6	69 \pm 4.0	75 \pm 5.1	61 \pm 5.6
<i>Medicago truncatula</i> cv. Caliph	3.7	98 \pm 2.0	88 \pm 2.5	82 \pm 2.9
<i>Ornithopus compressus</i> cv. Santorini	3.2	99 \pm 0.3	94 \pm 1.5	78 \pm 3.6
<i>Trifolium glanduliferum</i> cv. Prima	0.7	98 \pm 0.5	60 \pm 5.6	56 \pm 3.6
<i>Trifolium michelianum</i> cv. Frontier	0.7	86 \pm 7.7	15 \pm 6.1	4 \pm 1.3
<i>Trifolium subterraneum</i> cv. Dalkeith	6.7	79 \pm 1.9	18 \pm 1.0	14 \pm 3.0

Table 3. Seedling regeneration in the year after establishment (1999) and after a crop (2000) at Cunderdin, Western Australia
Values in parentheses are standard errors

Species and cultivar	1.iv.99 (plant/m ²)	28.v.99 (plant/m ²)	1.vii.99 (plant/m ²)	2.ii.00 (plant/m ²)	10.v.00 (plant/m ²)	30.vi.00 (plant/m ²)
<i>Trifolium dasyurum</i> cv. AGWEST Sothis	271 (74)	258 (73)	1433 (273)	17 (8)	306 (207)	1552 (87)
<i>Medicago polymorpha</i> cv. Santiago	300 (53)	579 (151)	0	172 (54)	272 (126)	0
<i>Medicago littoralis</i> cv. Herald	2933 (472)	1919 (692)	0	297 (81)	406 (64)	0
<i>Trifolium michelianum</i> cv. Frontier	967 (270)	1942 (509)	0	29 (8)	56 (36)	0
<i>Trifolium subterraneum</i> cv. Dalkeith	3225 (503)	2475 (135)	0	233 (32)	219 (22)	0

Table 4. Seedling regeneration (plants/m²) in second year (2001) after one pasture year at Pingelly, Western Australia

Values in parentheses are standard errors

Species and cultivar	24.v.01 (plant/m ²)	20.vi.01 (plant/m ²)	23.vii.01 (plant/m ²)
<i>Trifolium dasyurum</i> cv. AGWEST Sothis	716 (97)	1236 (348)	433 (159)
<i>Trifolium glanduliferum</i> cv. Prima	3730 (360)	0	0
<i>Biserrula pelecinus</i> cv. Casbah	4600 (443)	0	0
<i>Trifolium subterraneum</i> cv. Dalkeith	2211 (98)	0	0

90 (April) and 180 days (July) and the percentage of hard seed was recorded.

AGWEST Sothis is a hardseeded clover with a marked delay in seed softening. Its percentage of hard seed and its pattern of seed softening over the summer–autumn period are compared with other pasture legumes Table 2. AGWEST Sothis usually softens more rapidly in the second 90 day period, unlike *T. subterraneum* cv. Dalkeith and *Trifolium michelianum* cv. Frontier, which generally soften rapidly over the first 90 days and are exposed to risk of germination following false breaks. The high levels of hard seed at the end of summer (67%) of AGWEST Sothis combined with observations of excellent seedling regeneration (Tables 3 and 4) suggest that it is likely to be suited to self-regenerating ley systems or short-term phase farming systems (where it needs to be resown at the beginning of each pasture phase).

Using AGWEST Sothis as a tool for weed management

In regenerating pastures, the delayed germination of AGWEST Sothis is a useful tool for controlling weeds, particularly herbicide-resistant crop weeds in the pasture phase. Its long period of delayed germination allows the use of non-selective herbicides (and grazing where possible) for a period of up to 8 weeks (3–6 weeks preferably) after the break of the season to control >90% of the emerged weeds without compromising future legume production. The density of AGWEST Sothis is only moderately reduced by such an herbicide treatment compared with subterranean clover (65% cf. 3% seedling densities) but there is a marked decline in weed densities (Table 5).

The ability to control weeds early in the growing season is critical for successful pasture establishment. However, delayed sowing to allow consecutive knockdowns with non-selective

herbicides usually compromises pasture establishment and may limit the winter production of the legume. The yield penalty from late sowing of AGWEST Sothis appears to be much less (around 20%) than for current pasture legume species.

Herbicide tolerance

Results from herbicide trials conducted at Northam, WA, during 2003 and 2004 indicate that AGWEST Sothis is sensitive to many of the more common broadleaf herbicides including Bromoxynil, Tigrex, Spinnaker, Raptor and Broadstrike (Valentine and Ferris 2006). There are currently no broadleaf herbicides registered for use on eastern star clover. Grass weeds, however, can be safely controlled with selective herbicides.

Disease and pest tolerance

AGWEST Sothis is very susceptible to clover scorch [*Kabatiella caulivora* (Kirch.) Karak] and should not be grown where this disease commonly occurs (M. P. You, pers. comm.). However, the main target environment for this cultivar is the low to medium rainfall wheatbelt where clover scorch outbreaks are infrequent. AGWEST Sothis is also susceptible to chocolate spot (*Botrytis fabae* Sardina) and grey mould (*Botrytis cinerea* Pers.) and it should not be grown before or after grain legume crops (M. P. You, pers. comm.). No formal screening has been conducted for root rots or other foliar diseases. However, no obvious disease outbreaks have been noted in field plots (Loi et al. 2007).

Testing has indicated low to moderate sensitivity to redlegged earth mite (*Halotydeus destructor* Tucker) at the seedling stage. The cultivar is sensitive to cowpea aphids (*Aphis craccivora* Koch), which can reduce seed production. Blue green aphids (*Acyrtosiphon kondoi* Shinji) appear less damaging. Lucerne flea (*Sminthurus viridus* L.) has been observed to be less damaging in spring on AGWEST Sothis than in subterranean clover.

Seed harvesting

Seed of AGWEST Sothis can be harvested with modified grain harvesters, but seed is rapidly shed from the calyx and harvest efficiency can be low if harvest is delayed by uneven ripening. Best results will be obtained if the pasture is swathed to ensure even drying of the crop.

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Table 5. Plant densities of *Trifolium dasyurum* AGWEST Sothis, *Trifolium subterraneum* cv. Dalkeith and weeds in herbicide-treated and unsprayed treatments

Values in parentheses are standard errors

	Sown legume (plant/m ²)	Grasses (plant/m ²)	Herbs (plant/m ²)
AGWEST Sothis, unsprayed	722 (135)	6325 (3615)	3548 (939)
AGWEST Sothis, sprayed ^A	475 (84)	165 (32)	0 (0)
Dalkeith, unsprayed	5160 (992)	5295 (3152)	3682 (443)
Dalkeith, sprayed ^A	161 (30)	145 (61)	4 (3)

^APlots were sprayed on the 27 May 2004 (5 weeks after the first germinating rainfall) with a non-selective herbicide (glyphosate, 540 g a.i./ha).

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