Sulla *(Hedysarum coronarium)*
Management Package

pastures australia
A collaboration between AWI, GRDC, MLA, RIRDC & Dairy Australia




Produced by SARDI
With funding from Pastures Australia

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Authors

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Acknowledgements

Thankyou to Pastures Australia (a collaboration between AWI, GRDC, MLA, RIRDC and Dairy Australia) for their financial support of this project. Graham Crocker provided valuable contributions to this management package for which we are very grateful. Thanks to Rob Salmon, Kelly Burke, Tom Yeatman and Geoff Auricht for their comments on the manuscript. Many colleagues have contributed to the overall general knowledge of sulla in Australia and deserve special mention; David Lloyd, Alan Humphries, Ross Ballard, Steve Hughes, Geoff Auricht, Ron Yates and Graham Crocker. The excellent technical support of Peter Schutz, Kevin Foster, John Titterington, Daniel Kidd, Tony Cook, Peter Sanson and Bill Keene in preparing and maintaining trial sites for this project is greatly appreciated. We also wish to thank farmer collaborators Kelvin and Estelle Ridgway (Narrikup, WA), Trevor and Lee Polkinghorn (Petersville, SA) and Research Station staff for their inputs and co-operation.

Disclaimer

Funding

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Contents

Comparison of main characteristics between sulla, lucerne and subclover/medic pastures

Characteristic	Sulla	Lucerne	Subclover/medic
1. Forage quality (spring)	High	High	High
2. Forage quantity (spring)	High	High	Moderate
3. Palatability	Very High	Moderate	Moderate
4. Contains condensed tannins	Yes • Reputed anthelmintic properties - reduced internal parasite burdens • By-pass protein protection - promotes high growth rates in livestock • Minimises scouring of livestock	No	No
5. Bloating	Non-bloating	Can cause bloat in pure stands	Can cause bloat in pure stands
6. Plant type	Short-lived perennial (2 years) • Deep roots, minimises ground water recharge	Perennial • Very deep roots, minimises ground water recharge	Annual - self regenerate from seed bank • Shallow roots, poor ability to reduce ground water recharge
7. Hay	Hay retains leaf • High quality hay • Minimal or no irrigation required for hay production • High palatability, livestock eat leaf and most stalks	Hay can lose leaf • High quality hay	• Moderate quality hay
8. Seed production	Can reap own seed • Seed difficult to dehull • Soft seeded variety being bred	Can reap own seed • Seeds thresh relatively easy	Seed harvested by specialised vacuum harvester, • Erosion risk • Seeds thresh relatively easy
9. Irrigation/rainfall during summer	Dormant during summer - does not respond to irrigation or rain • Very little feed if any produced over summer	Summer active types – respond well to irrigation and rain • Provides good summer feed	Some germination of the more soft seeded types eg. subclovers • Very little feed if any produced over summer
10. Waterlogging	Not tolerant	Moderate tolerance	Subclover subspecies *yanninicum* moderate to high tolerance
11. Grazing	Rotational graze • Slow recovery from grazing or cutting	Rotational graze	Subclovers can be set stocked, tolerant of heavy grazing
12. Level of management	High level required to maintain stand	High level required to maintain stand	Moderate level required to maintain stand
13. Herbicide options	Limited range of herbicide options. • No recommendations for Australia • Easily removed at end of pasture phase	Broad range of herbicide options • Can be difficult to remove at end of pasture phase	Broad range of herbicide options • Easily removed at end of pasture phase
14. Varieties available	Limited range available	Wide range available with different winter activity ratings	Diversity of medic and subclover varieties for widespread use from low to high rainfall zones
15. Drought tolerance	Moderate	Moderate – will drop leaf during hot dry conditions	Low drought tolerance for subclovers, some medics able to produce some seed under low rainfall conditions
16. Soil pH	Mild acidic to high alkaline • Tolerates free lime	Mild acidic to alkaline	Medics – neutral to alkaline Subclovers –moderate acidic (ssp. *subterraneum* and *yanninicum*) to mild alkaline (ssp. *brachycalycinum*)
17. Farming system	Short-term (2 – 3 year) pasture phase • Finish prime lambs and beef • Fodder (hay/silage for dairy)	Long-term pasture phase • Finish prime lambs and beef • Fodder	Medics- short-term, hard seed can go through 1 – 2 years crop without re-sowing Subclovers – varieties vary in their hardseed content; consistent regeneration for long-term pasture phases

1. Sulla – a specialist pasture legume with exciting potential

1.1 What is sulla?

Sulla *(Hedysarum coronarium)* is a highly productive, short lived perennial pasture legume with moderate drought tolerance. Individual plants live for 2-3 years, but it will regenerate from seed and is highly palatable, with excellent forage and fodder quality, resulting in increased animal performance. It is a widely used perennial forage legume in central and western Mediterranean countries.

1.2 Why should you consider growing sulla?

Sulla can be used as a specialist crop for short pasture rotations in both mixed farming and livestock production systems. It can be used for grazing, hay and silage production and contains condensed tannins that prevent bloat, increase protein digestion by livestock and make the plants less attractive to insects. Overseas experience has shown increased weight gain, wool growth, milk production and ovulation rates in sheep feeding on sulla foliage.

1.3 Description

Sulla is a branching, semi-erect to erect (0.3 to 1.6 m in height) biennial or short lived perennial with a deep branching taproot. The leaves are pinnate (fern-like) divided into 5-15 pairs of oval to round leaflets and a terminal leaflet. The upper surface of leaflets is hairless and lower surface hairy. The stems are thick and succulent, becoming woody after full flowering. The plants produce 10 to 35 light pink to bright red crimson flowers, each 3-6 mm long.

Second year sulla showing the height of the stand pre-flowering, approximately one metre tall (photo by P. Schutz, SARDI)

Sulla flowers and foliage (photo by P. Schutz, SARDI)

Flowering commences in mid spring to early summer (depending on cultivar) and pods mature about 8 weeks later. Seed pods have 3 to 8 egg-shaped segments per pod, which split into un-hulled seeds with a rough, thorny surface. Each segment contains 1 creamy white to dark brown seed about 3 mm in diameter, flattened with an almost circular profile. There are between 200,000 and 280,000 seeds/kg.

The size and shape of sulla seed and pods (photo by P. Schutz, SARDI)

1.4 Attributes of sulla

i. Growth pattern

Under ideal conditions of adequate moisture and optimal temperatures sulla can produce up to 10 tonnes dry matter/ha in the first year and over 20 tonnes dry matter/ha in the second year. Spring growth rates can be over 100 kg dry matter/ha/day for 2 months.

Sulla grows well in autumn, late winter, spring and early summer (Figure 1), however it becomes dormant under hot summer conditions and will not grow following heavy rainfall or even irrigation.

Growth during winter months is low due to cold soil temperatures and the short day length.

Autumn rains promote high growth rates influenced by the combination of optimal soil temperatures and ideal day lengths.

ii. Root system and nitrogen fixation

Sulla has a deep (over 2 m), strong branching taproot, which gives good drought tolerance and extended growth into spring. However, early seedling growth is slow while it establishes the root system. With effective nodulation and sulla's high production capability total soil nitrogen levels could increase by over 100 kg/ha in the first year and more than 200 kg/ha in the second year when grazed. However, not all this nitrogen is available at once, it is slowly released over a period of 3-4 years.

First year sulla plant showing branched tap root, note no nodules (photo by T. Polkinghorn, Petersville, SA)

Sulla roots with nodules (photo by C. de Koning, SARDI)

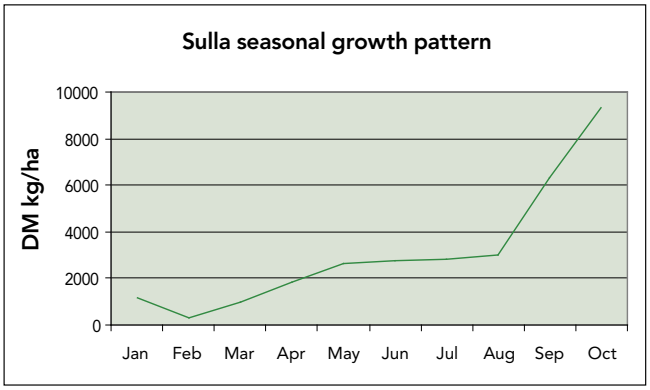


Figure 1: Seasonal growth pattern of sulla in the second year, Mount Torrens, SA
(source: E. Marshall & A. Humphries, SARDI)

iii. Hard seed content

Generally sulla seed is not very hard seeded when compared to other pasture species (in order of softest to hardest; sulla ≤ subclover < annual medics). Hard seed break down in the field over the summer months is rapid in South Australia and northern NSW / southern QLD and slower in Western Australia (in WA hard seed levels range from 60-80%). However, storage of pod in a shed over the summer months is not conducive to hard seed break down.

iv. Palatability

The herbage of sulla is highly palatable, highly nutritious, non-oestrogenic and comparable to lucerne. Livestock will selectively graze sulla when sown in a mixed sward. Quality peaks just before flowering, however once flowering starts stems become more fibrous and the foliage is less palatable.

v. Medicinal value

Sulla contains condensed tannins, which prevent bloat and reduce protein degradation in the rumen, increasing nitrogen absorption. This may lead to improved livestock performance including increased live weight gain, wool growth, milk production and ovulation rates in sheep (based on overseas data).

Tannins act as a natural chemical defence against insect damage, and can also produce an anti worming (internal parasites) or 'anthelmintic' effect in sheep and reduce the incidence of flystrike due to less scouring (based on overseas data).

2. Adaptation

2.1 Soil type

Sulla prefers slightly acid to alkaline soils (5.5 – 8.5 in $CaCl_2$), sandy loams, loams to clays. Better growth is achieved on the more alkaline soils. It is very tolerant of free lime and can handle transient water-logging, but does not like prolonged water-logging, saline (moderate to high salinity) and sodic soils. Sulla has performed poorly on acidic soils in southern New South Wales where it was shown to be less tolerant than lucerne. However, field trials undertaken in the south-west of Western Australia on acid soils (pH 5.0) have revealed that successful nodulation of sulla is reliant upon increasing the inoculation rate, providing there is ample applied mineral fertiliser. Poor nodulation has been overcome by a 4-fold increase in inoculation rate, much more so than the addition of lime (refer to section 4 on inoculation).

2.2 Rainfall and growing season length

Sulla can be grown in regions receiving 400 mm – 1200 mm Average Annual Rainfall (AAR). In northern areas (southern Queensland and northern NSW) it requires at least 550 mm AAR. In South Australia it will grow at 400 mm AAR. In Western Australia it requires a growing season of at least 5.5 months.

2.3 Climatic region

In Australia, sulla grows in Mediterranean, temperate and sub tropical regions, it is suited to similar areas as lucerne. Consecutive severe frosts can be very damaging, but it can recover from one or two frosts.

Frost damage on second year sulla plants (photo by G. Crocker, formerly with NSW DPI)

2.4 Where does sulla fit in the farming system?

Sulla can be used to produce good quality hay and silage (dairy industry), it can also be grazed (see section 7) to finish prime lambs and beef cattle. Sulla may have a role as a pasture legume in short-term rotations in cereal cropping. The ability of sulla to produce high dry matter has the potential to increase nitrogen and organic matter for cereal cropping systems. Furthermore, as sulla plants end their lifecycle the decaying root system will leave bio-pores (channels) throughout the soil increasing water infiltration and decreasing runoff. Sulla is much easier to remove at the end of the rotation than lucerne. Some sulla plants remain green (but dormant) over summer, however they would not provide the same level of ground cover as summer active lucerne.

2.5 Regeneration in the second and third year

Plant numbers will be reduced during summer and plant survival is influenced by the severity of summer, (i.e the longer and hotter the summer the more plants will be lost). Almost all plants survive the mild summer conditions of Tasmania, whereas in South Australia losses can be well over half of the population. Plants are quick to respond to autumn rains, their growth is triggered by cooler autumn temperatures and shorter days. Second and third year stands may also have seedlings emerge provided the sulla stand was allowed to set seed in the previous year. Large numbers of seedlings will undergo self-thinning as they compete for moisture with other seedlings and adult plants. To ensure good seedling regeneration, knock seed heads to the ground by mowing dry residues or lightly grazing during summer (see section 7).

Green dormant sulla plants January 2009 in a 2 x 2 m area (photo by P. Schutz, SARDI).

Green dormant sulla plants February 2009 in a 2 x 2 m area (photo by P. Schutz, SARDI).

Close-up of green dormant sulla plants in summer (Photo by P. Schutz, SARDI).

Green dormant sulla plants March 2009 in a 2 x 2 m area, note plant numbers are reduced (photo by P. Schutz, SARDI).

Seedlings emerging among adult plants in the second year. Note, early in the growing season adult plants form a rosette (photo by C. de Koning, SARDI)

3. Paddock Selection

3.1 Seedbed preparation

Establishment is similar to other small seeded legumes. Weeds should be controlled before sowing to maximise moisture and nutrients available to the emerging crop.

Ensure seed is sown into a moist seed bed with good seed soil contact.

Weeds in a seedling sulla stand (photo by K. Burke, Wrightson Seeds Aust.)

3.2 Weed control

Sulla seedlings are slow to establish and compete poorly with weeds. There are currently no herbicides registered for control of weeds in sulla, therefore it is advisable to sow sulla in paddocks which are relatively free of weeds as weed control after emergence could be difficult. Refer to section 5 for more information.

Sulla wilting in spring time on shallow soil with lime stone close to the surface (photo by C. de Koning, SARDI)

3.3 Soil type

Sulla prefers fertile soils. Do not sow in areas prone to waterlogging and avoid soils with high salinity, sodicity and a pH ($CaCl_2$) below 5.5 as production will be significantly reduced.

Wilting patches in spring time first year sulla stand (photo by P. Schutz, SARDI)

Irregular wilting patches may appear in sulla stands during dry spring conditions on soils with shallow profiles and limestone close to the surface (see photos).

4. Sowing

4.1 Varieties

There are at least 4 varieties released overseas and three varieties in Australia (Wilpena, Moonbi and Flamenco). The Australian varieties have all been selected for Australian conditions being earlier flowering with increased forage and seed production than New Zealand derived varieties (Necton and Aokau) Australian varieties are protected by Plant Breeders Rights (PBR). All three can be grazed so long as plants are no taller than 30 – 40 cm at the commencement of grazing.

i. Australian Developed Varieties

Wilpena is an erect, mid to late maturing variety (flowering 123 days after an early June sowing at Tamworth).

- Dual purpose variety, but is more suited to forage, hay or silage than grazing.
- Bred by SARDI in collaboration with NAPLIP (National Annual Pasture Legume Improvement Program) partners DPI&E Queensland and DPI NSW.

Wilpena sulla in flower (photo by C. de Koning, SARDI)

Wilpena vegetative growth habit. Note, taller than Moonbi (photo by C. de Koning, SARDI)

Moonbi is a semi-erect variety with a strong crown and is slightly earlier maturing than Wilpena.

- Suited to grazing and forage systems.
- Moonbi has the highest hard seed content at the end of summer, although this is still low compared to other pasture species (eg. annual medics).
- Shorter than Flamenco and Wilpena.
- Bred by SARDI in collaboration with NAPLIP (National Annual Pasture Legume Improvement Program) partners DPI&E Queensland and DPI NSW.

Moonbi sulla in flower (photo by C. de Koning, SARDI)

Moonbi vegetative growth habit. Note, shorter than Wilpena (photo by C. de Koning, SARDI)

Flamenco is an erect variety

- Bred by DAFWA with support from RIRDC
- Released in Western Australia for increased seed production from material collected in Tunisia.
- Suited to grazing and forage systems
- Slightly earlier flowering than Moonbi.
- Taller than Wilpena and Moonbi.

Flamenco sulla in full flower (photo by R. Yates, DAFWA)

Kelvin Ridgway of Narrikup, WA, standing in a Flamenco sulla first year stand (16/10/2008) (photo by R. Yates, DAFWA)

ii. Overseas Varieties

Aokau is a late flowering New Zealand variety with semi-erect growth and developed primarily for soil conservation purposes, but also used for forage. Selected from lines originating in Italy, Morocco and Portugal.

Necton is another New Zealand variety, more erect than Aokau and bred for hay, silage and grazing. It was selected from lines originating from Spain, Italy, Morocco, France and Switzerland.

4.2 Inoculation

Sulla needs to be inoculated with its own specific root-nodule bacteria (*Rhizobium sullae* - strain WSM 1592) for optimum nodulation and maximum nitrogen fixation. The majority of Australian soils do not contain *Hedysarum* rhizobia and thus inoculation is essential. Inoculants for sulla seed may be prepared for commercial distribution in peat or in granular carriers. Additionally, seed may also be sold in a pre-coated form with inoculum as part of the pellet, however the shelf life of these products is very short. All forms of inoculant carry live cells of root-nodule bacteria and must be stored according to instructions to preserve high numbers (cool and dry).

For traditional peat-based products, inoculum is applied as a slurry (with adhesive solution) to the surface of the seed so that root-nodule bacteria are in direct contact with the seed. The seed should be dried with lime for ease of handling and sown within 24 hours (preferably as soon as possible) to achieve maximum survival rate of bacteria. New recommendations will instruct the use of 4 packets of peat (250 grams) in slurry to every 50 kg of sulla seed. Slurry inoculated seed has resulted in double the number of seedlings with nodules (75% of seedlings with nodules) compared to pre-coated seed (35% of seedlings with nodules).

Rhizobia nodules on sulla seedlings (photo by R. Yates, DAFWA)

4.3 Sowing rates

i. Seed

Sulla seed is approximately twice the size of lucerne seed and should be sown at 5 to 10 kg/ha (de-hulled seed).

ii. Pods

Seed can be sown in the pods, but dehulled seed gives faster and more uniform establishment. Pods have short spines, which slow its flow through seeding machinery. Due to the unreliability of germination and nodulation, pods should be sown at 20 to 40 kg/ha. The target plant establishment density in the second year is 25 plants/m2.

Sowing rate trial showing in foreground 1kg/ha, followed by 7.5, 5 and 15 kg/ha(background)
(photo by G. Crocker, formerly with NSW DPI)

4.4 Depth of sowing

Sulla should be sown at 1 to 2 cm deep based on a loam soil and certainly no more than 3 cm as plant establishment is significantly reduced when sown below this depth (Figure 2 & 3). Ensure good seed soil contact and moisture retention by either sowing with press wheels or rolling after sowing. Seed can be broadcast and then lightly harrowed into the soil or drilled. Broadcasting and then harrowing or prickle chaining maybe the best option for sowing pods onto areas that have recently grown sulla.

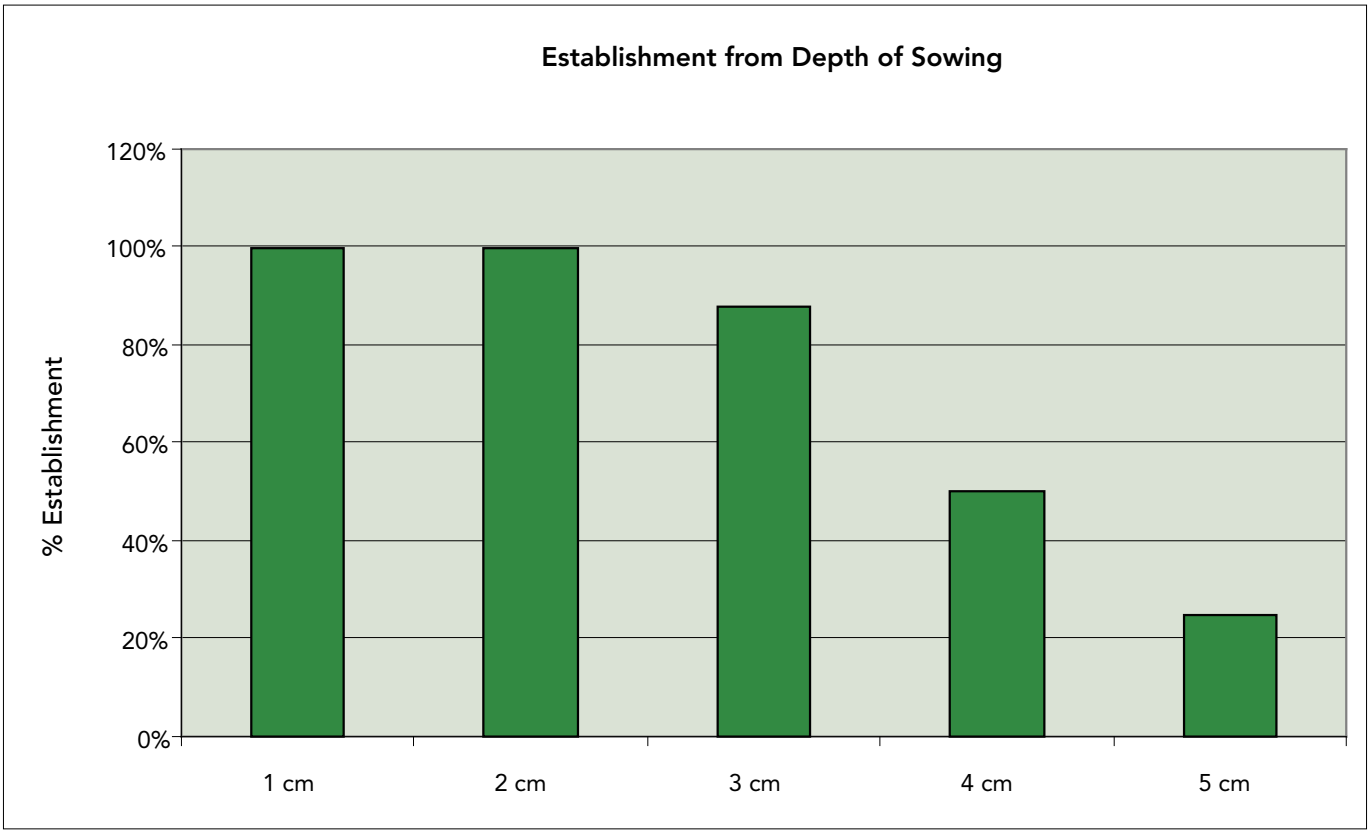


Figure 2: Establishment of sulla seeds from various depths using loam soil in a pot experiment
(G. Crocker, formerly with NSW DPI).

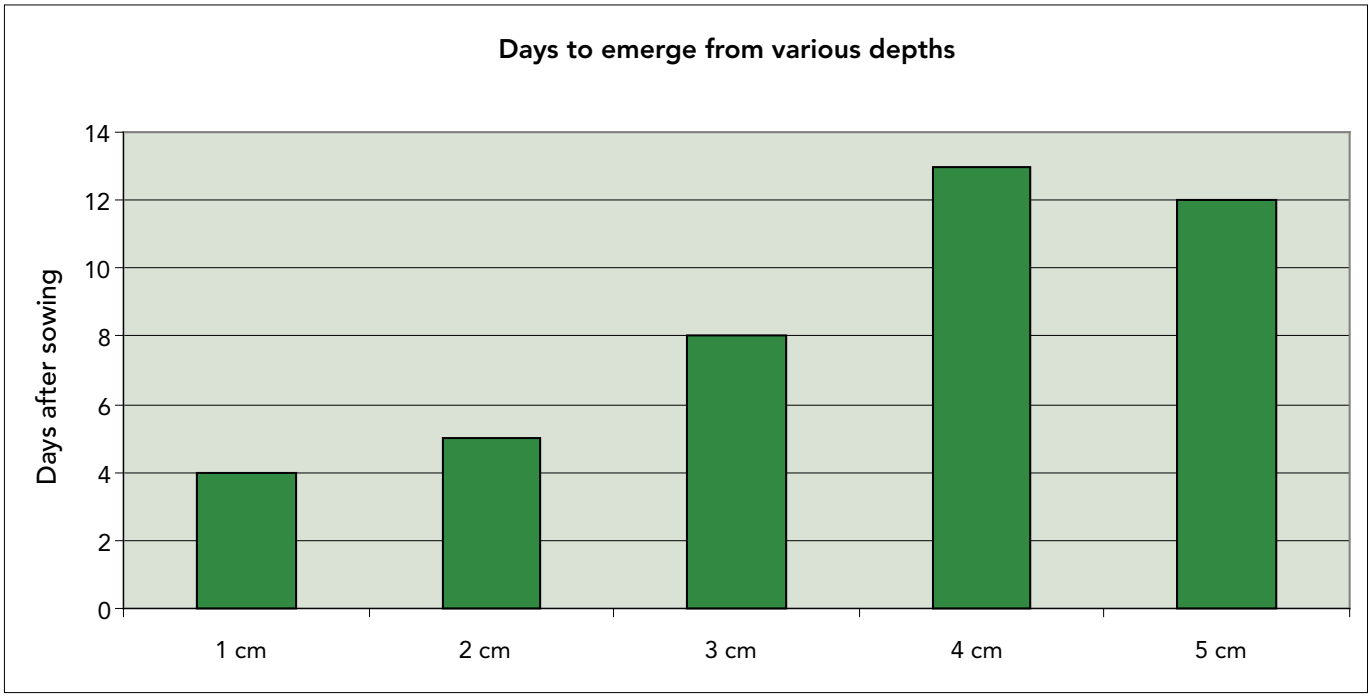


Figure 3: Number of days for seedlings to emerge from a loam soil when sown at various depths, pot experiment (G. Crocker, fomerly with NSW DPI).

4.5 Fertiliser application

As a legume adequate amounts of P and S need to be applied for optimal growth of sulla. Generally 10 – 15 kg P /ha and 10 kg S /ha (dependant on soil type) should be applied annually along with any other nutrients known to be deficient. Check your soil test results.

4.6 Time of sowing

The optimum sowing time is early to late autumn. This allows the plants to develop before winter as frequent frosts below -4°C will severely affect the growth of small plants. Soil temperatures above 8°C to 10°C are ideal for sulla seed germination, the majority of seeds will germinate by day 5 and 6. Once temperatures drop to 5°C, germination of sulla seed is dramatically slowed compared to other pasture species and can take 11 days to reach 75% germination compared to subclover (7 days) and lucerne (6 – 7 days).

Sowing in spring is not recommended in northern New South Wales or southern Queensland because plants become dormant under high summer temperatures. In southern Australia, spring sowing is possible provided there is subsoil moisture and may be preferable in high rainfall cold districts. Spring sowing enables better weed control prior to sowing, especially with a late seasonal break preventing autumn sowing.

A late winter early spring sowing will reduce the level of flowering in the sulla sward, however over summer survival maybe enhanced as sulla plants have not expended a lot of energy into producing seed.

4.7 Cover crops

The use of cover crops such as oats or barley can provide early grazing, reduce the risk of sand-blasting and increase competition with weeds, however they can also compete strongly with sulla seedlings even at low sowing rates. Oats were trialled as a cover crop at various sowing rates at Tamworth, NSW, however they were far too competitive for the sulla plants. Other types of cover crops such as barley, wheat and grazing brassica have been trialled. Barley and wheat provided the best winter dry matter production when sown at 80 kg/ha (15 cm row spacing) with sulla sown at 7.5 kg/ha. Both cereals at the 80 kg/ha sowing rate dramatically reduced the number of weeds with minimal reduction in sulla production during winter. Grazing brassica competed poorly even at the highest sowing rate of 3 kg/ha. Grazing cover crop/sulla combinations will need to be monitored carefully as sulla is highly palatable and may be grazed in preference to the cover crop. The best option is to establish a cereal cover crop with sulla and then spray out the cereal using a grass selective herbicide in midwinter to reduce competition in late winter and spring. This will provide some early grazing and protect young sulla seedlings from sand-blasting with minimal competition later in the season. Ungrazed or uncut cover crop/sulla combinations with wheat and barley may result in excessive sulla growth under

favourable conditions whereby the sulla maintains a height similar to the cover crop. This will make it difficult to harvest the grain cleanly from the cover crop as green sulla plant material will also be taken into the harvester. The uncut or ungrazed cereal cover crop may also compete strongly with sulla if spring conditions suddenly become dry.

Sulla under-sown with a cereal crop (photo by P. Schutz, SARDI)

Barley cover crop (sown at 40 kg/ha) and sulla in late spring, note, the height of the sulla (photo by C. de Koning, SARDI)

4.8 Plant establishment

First year stands can range between 80 – 150 seedlings/m^2 (based on 5 – 10 kg/ha sowing rates). Plant top growth is slow while the plant invests much of its energy into developing the root system. Self thinning will occur particularly if spring conditions become dry. Over summer survival is influenced by the length and severity of summer temperatures. Plants also survive summer in higher numbers if they have not flowered and set seed profusely in the first year. High seed production can weaken the plant.

A target establishment density of 25 plants/m^2 in the second year is desirable, however, reasonable production can still result from 10 – 15 plants/m^2. Second year stands can comprise a mixture of adult plants (from year 1) and new seedlings (if seed was set at the end of year 1). It is possible to keep a stand of sulla going beyond year 2 so long as seed has been set at the end of each year, however good weed control needs to be maintained.

4.9 Mixtures with other pasture species

Phalaris, tall fescue and Italian ryegrass are suitable to mix with sulla. However, it is important to sow the sulla in the first year and then sow the grasses in the second year. Tropical C_4 grasses are not suitable for growing with sulla.

4.10 Green manuring

Sulla has potential to be used as a green manure crop in the second year, due to its high dry matter production. At the early flowering stage the crop could be killed with a disc or knife roller to provide high levels of nitrogen for the following crop.

5. Weed Control

Sulla seedlings are slow to establish and compete poorly with weeds. Therefore it is essential to use a combination of rotation, cultural practices and herbicides to reduce weed levels before sowing.

There are currently no herbicides registered for use on sulla. It is unlikely that any chemical companies will register products in the near future, due to the high cost involved. State chemical user legislation prevents any chemical use on sulla until registered for use on sulla or approved by permit issued by the Australian Pesticides and Veterinary Medicines Authority.

The following herbicide tolerances and trial use indicate some herbicide opportunities for registration or permit.

5.1 Pre-emergent products

Knockdown herbicides such as glyphosate and paraquat can be used before sowing to control a range of grass and broadleaf weeds.

Trifluralin has been applied pre-sowing to sulla stands, in situations where no grasses were being sown with the sulla.

Limited trial work on other products has shown that normally recommended rates of metolachlor (Dual Gold®) and simazine cause unacceptable damage, while imazethapyr (Spinnaker®) produced minimal damage to sulla stands.

5.2 Post-emergent products

Trial work is limited but a range of herbicide products have been successfully applied post emergent to sulla at spraying rates used for legume based pastures. These have included bentazone (Basagran®), imazethapyr (Spinnaker®) and flumetsulam (Broadstrike®), however none of these are registered for use in sulla. These products have caused phyto-toxic effects (eg. yellowing), but under normal seasonal conditions plants will recover with minimal dry matter reductions. However, losses in seed production have been noted.

Applications of 2,4 DB, bromoxynil + diflufenican (Jaguar®) and bromoxynil have caused unacceptable damage to both seedling and second year stands.

Distortion and damage on young sulla plants caused by the application of 2,4DB, 3-4 weeks earlier.
(photo by T. Cook, Division of Industry & Investment NSW).

Healthy un-sprayed young sulla plants.
(photo by T. Cook, Division of Industry & Investment NSW).

2,4DB sprayed plot showing herbicide damage in spring, note the lack of plants and no flowers.
(photo by T. Cook, Division of Industry & Investment NSW).

View of un-sprayed plot, note the sulla plants are flowering unlike the corresponding 2,4DB plot. (photo by T. Cook, Division of Industry & Investment NSW).

6. Pests and disease management

At this stage there is limited information on the pests and diseases of sulla in Australia. No doubt more pests and diseases will emerge as sulla becomes more widely grown. However, glasshouse trials have shown sulla to be resistant to blue green and spotted alfalfa aphids.

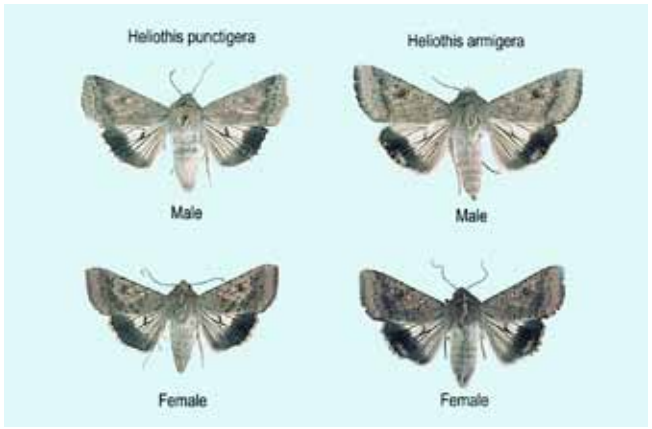
6.1 Lucerne seed wasp

Lucerne seed wasp (*Bruchophagus roddi* (Gussakovski)) can attack sulla and reduce seed set. This is most likely to happen in areas where lucerne is widely grown. Spraying insecticide is not recommended but good sanitation practices (mowing, grazing and herbicide spraying) of non-seed crop lucerne stands and early closure of lucerne seed crops does reduce the presence of the pest (De Barro 2001). Female wasps lay eggs onto soft developing seeds on which the larvae feed.

Adults are shiny black wasps 3 mm long. Larvae are white legless and pupate within the seed (photo © Division of Industry and Investment, NSW)

6.2 Native budworm (Helicoverpa species)

Helicoverpa can cause significant damage by reducing dry matter and seed yield production. Significant damage (all leaves stripped from plants) can occur to sulla during mid flowering and reduce seed yield particularly for the later flowering types. Moths swarm during August and September.



Adult moths (photo: DAFWA)

Larvae size categories: Large (23 mm plus), medium (7-23 mm), small (3-7 mm), very small (1.5-3 mm) (photo by SARDI entomology)

6.3 Mites

Red legged earth mite (RLEM) can cause light to moderate damage to sulla. Most damage is caused to cotyledons at the seedling stage. RLEM damage on sulla is characterised by leaf distortion, light silvering on the upper leaf surface and bronzing on the underside of the leaf, rather than the prominent silvering as seen with other pasture legumes.

RLEM on the leaf of sulla (photo by P. Schutz, SARDI)

RLEM damage on sulla, showing distortion of the leaf and light silvering on the upper leaf surface (photo by P. Schutz, SARDI)

6.4 Root diseases

Sulla is susceptible to root rot caused by *Rhizoctonia solani* and there is generally a low level of resistance to this organism. Sulla is also susceptible to another root rotting organism, *Sclerotium rolfsii*, this has been visually observed and identified from black earth soils on the Darling Downs in Queensland. *Rhizoctonia* type patches have been observed in sulla stands, however pathology tests may not always find traces of fungal hypha. In a pot trial (conducted in northern NSW) where sulla was flooded and inoculated with *Phytopthora medicaginis*, sulla was shown to be a susceptible host of this root rot pathogen.

Rhizoctonia type ring in sulla Rosedale, South Australia (photo by P. Schutz, SARDI)

Rhizoctonia type ring in sulla Petersville, South Australia (photo by T.Polkinghorn, Petersville, SA)

6.5 Foliar diseases

Phoma blight (Black Spot) has been observed on sulla leaves in Western Australia. In northern NSW powdery mildew has infected sulla. Powdery mildew is a common problem in overseas (Italy) sulla stands. The significance of these foliar diseases has yet to be determined.

Powdery mildew on sulla (photo by G. Crocker, formerly NSW DPI)

7. Management (Main Uses)

7.1 Hay and silage

Sulla can be made into high quality and highly digestible hay and silage, however, it is not recommended to cut sulla for hay or silage in the first year. First year sulla stands will be severely weakened if cut late in spring for hay and silage. Normally the dry matter yields are considerably higher in the second year, therefore it is best to make hay or silage in the second year.

Silage made with high sulla content (eg. 75% and higher) increases the level of lactic acid resulting in the reduction of ammonia concentration and lower pH leading to high quality silage. Sulla also has a high water soluble carbohydrate content which enhances silage quality. Sulla is usually cut for silage at early flowering and cut with a fine chop forage harvester.

Hay should be cut before peak flowering, preferably around 10% flowering. The use of a mower-conditioner (eg. "super squeezer") will shorten the drying time particularly of stems. Aim for quality not quantity. The decision to make hay needs to be made early in the season for sulla dry matter yield is dramatically influenced by cutting/grazing frequency and timing (Figure 4), particularly under dry seasonal conditions. Cutting well into flowering is too late and quality will be much lower despite higher yields, due to an increased proportion of stems (Figure 5).

Sulla hay retains most leaf if conditioned and raked carefully. Cut the sulla 20 – 30 cm from ground level so that the cut sulla can dry off the ground supported by the cut stems. If at all possible don't rake as leaf will be lost and quality reduced. Sulla hay has good nutritive value (Table 1) and is highly palatable despite thick stems, and livestock (cattle, sheep, horses and alpacas) will readily eat most of the stems.

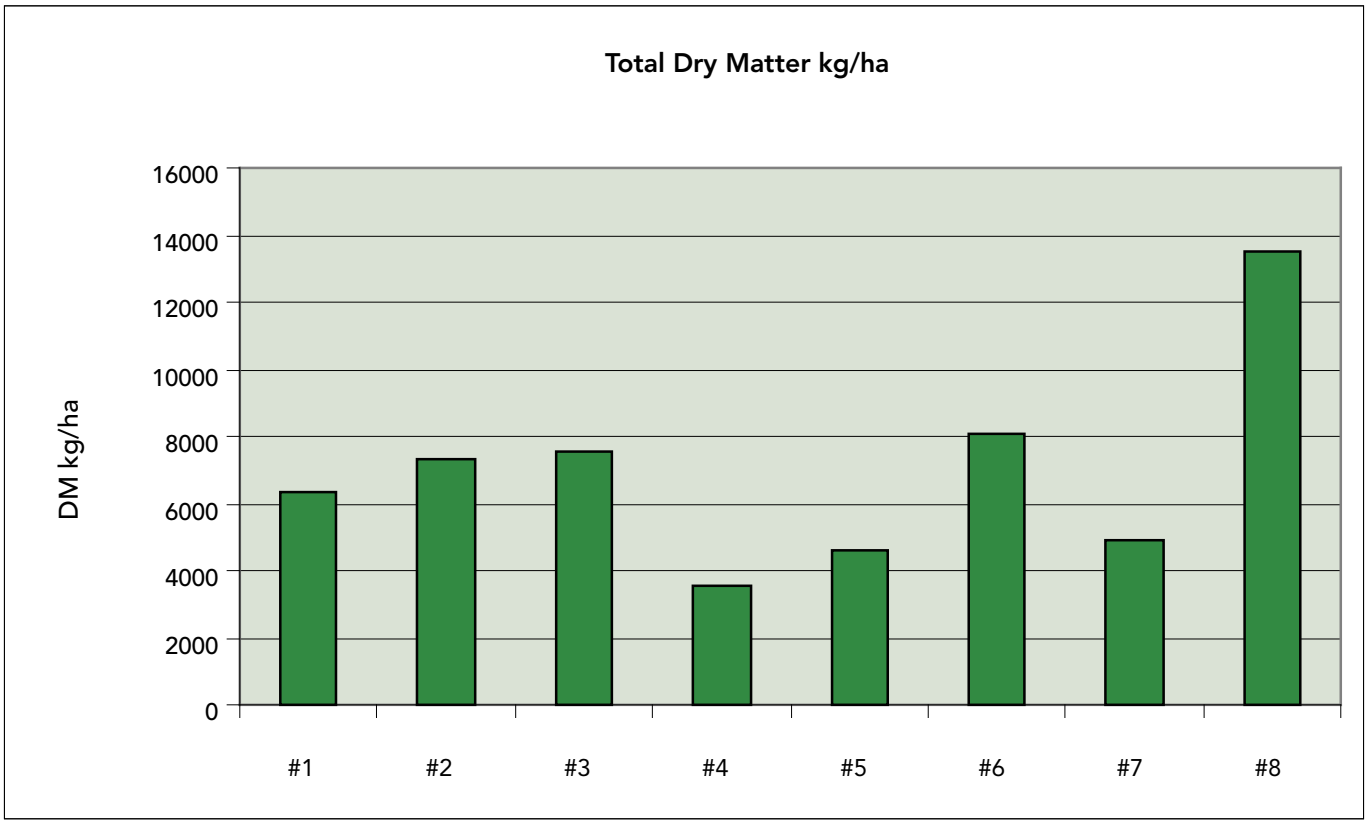


Figure 4: The effect of various defoliation regimes on the total dry matter, second year stand

Treatment #1 = cut only once 6 weeks after break of season
Treatment #2 = cut only once mid winter (stem elongation)
Treatment #3 = cut only once spring (early flowering)
Treatment #4 = cut three times in season (#1, #2 & #3)
Treatment #5 = cut twice in season (#1 & #2)
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Treatment #7 = cut every 30 days
Treatment #8 = uncut

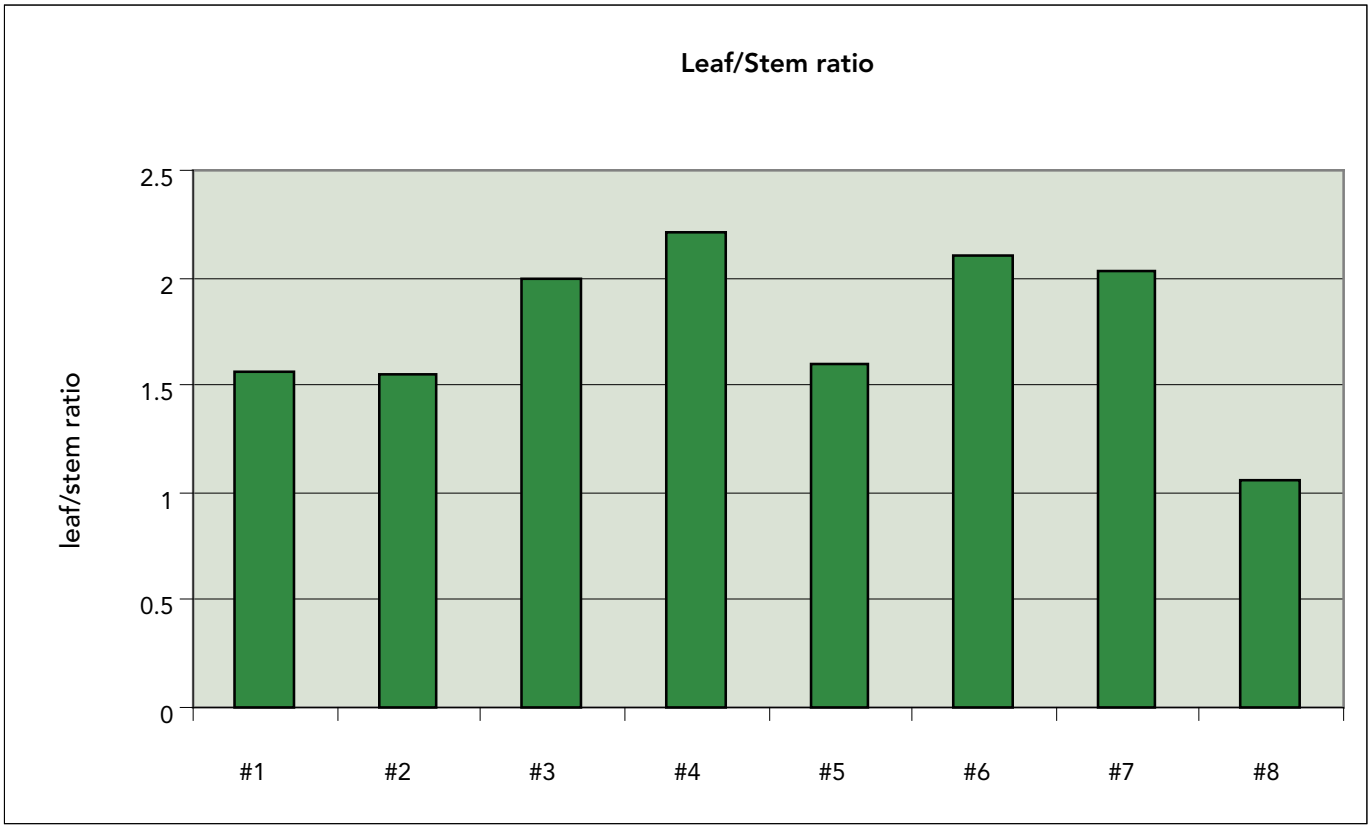

Figure 5: Leaf/stem ratio of sulla under different defoliation regimes, second year stand. (See pg 18 for treatments).

Sulla stand cut for hay (photo by P. Schutz, SARDI)

Sulla stand being cut for hay (photo by P. Schutz, SARDI)

Table 1: Nutritional value of "Wilpena" sulla fresh cut (10% flowering stage) in spring and dry hay (made into large 4' rounds), Turretfield Research Centre, Rosedale, South Australia, 2008.

	Fresh cut 24.09.08	Dry Hay 7.11.08
Moisture %	84.8	18.0
Dry Matter (DM) %	15.2	82.0
Crude Protein % of DM	17.3	13.5
Neutral Detergent Fibre % of DM	33.0	42.7
Digestibility of DM (DMD) % of DM	75.1	67.5
Digestibility of organic DM (DOMD) % of DM	70.4	64.0
Metabolisable Energy (MJ/kg DM)	11.3	10.0

Source: FEEDTEST, Hamilton, Victoria

7.2 Grazing management

In the establishment year sulla should be lightly grazed to ensure good root development and plant numbers for the second year. Rotational grazing is the best grazing strategy for sulla based pastures. The rest period between grazing is longer than required for lucerne and can range from 35 to 85 days (regrowth of 30 – 40cm high). This depends on the level of moisture, day-length and soil temperature.

Do not graze below 10cm as this will delay regrowth. Crash grazing is too damaging and sulla does not tolerate set stocking as it is preferentially grazed. For example, sheep reduced the average sulla content from 46% down to 18% while set stocked on a sulla based pasture in South Australia.

Grazing during wet soil conditions should be avoided as this can result in pugging damage from hooves. Pugging damage is greatest from cattle.

7.3 Livestock production

Sulla is ideal for finishing prime lambs or beef cattle due to enhanced growth rates. Sulla also has the capacity to increase milk production in dairy herds (New Zealand research). A grazing experiment at Turretfield Research Centre, Rosedale, SA comparing sulla based pasture with a grass/subclover pasture (control pasture) revealed better growth rates (144 g/hd/day vs. 103 g/hd/day, sulla and control pasture respectively) and wool growth (sulla sheep grew longer wool than control pasture sheep) for ewe hoggets that grazed sulla during winter for 8 weeks.

On average the sheep grazing sulla were 2.65 kg/head (live-weight) heavier than control pasture sheep at the end of 8 weeks grazing in winter. Both pasture types were of similar nutritive value at the start of the experiment. Sheep that had grazed sulla remained heavier leading into summer.

Twenty-five percent of control pasture sheep had dags whereas only 4% of sulla grazed sheep had dags. Therefore sulla may have a role in minimising scouring of livestock. Faecal egg counts (FEC) were made before and after grazing but no significant differences were found, mostly because FEC were low to begin with and both pasture types had low larval counts. Anthelmintic properties are yet to be confirmed under Australian conditions.

Sheep grazing sulla in winter (photo by P. Schutz, SARDI)

7.4 Nutritive value

Sulla has similar nutritive value to lucerne, without the risk of bloating. In addition, sulla contains condensed tannins that enable protein to be protected from degradation in the rumen allowing for more effective absorption later in the digestive tract promoting greater growth rates. The high nutritive value of two varieties in early winter is shown in Table 2. Spring nutritive value is shown in the earlier Table 1.

Notably nutritive value declines in spring if the sulla stand is uncut or ungrazed. However, if the sulla stand has been grazed throughout winter the nutritive value leading into spring will be relatively high (Table 3) due to higher leaf to stem ratios.

Mid spring grazing value of sulla based pastures is much higher than grass/clover based pastures providing greater bulk and nutritive value for a greater length of time. For example, a third year sulla based pasture (the grass component was annual ryegrass that had gone to seed) in southern Australia yielded 6.4 t/ha Total Dry Matter mid to late October 2009. At the same time a barley grass/ clover pasture yielded 4.9 t/ha Total Dry Matter, with the barley grass still green but running to head. The nutritive value of the sulla component was relatively high (16.5% crude protein, 68 % digestability, 42.8 % Neutral Detergent Fibre and 10.1 Metabolisable Energy (MJ/kg/DM)) compared to the grassy pasture (14.6 % crude protein, 61.5 % digestability, 55.6 % NDF and 9.0 ME). Ewe hoggets that had grazed sulla based pastures in South Australia during mid spring for 28 days (4 paddock rotation), gained on average 4.94 kg/head live-weight whereas the ewe hoggets on grass/clover pastures had lost 2.64 kg/head.

Table 2: Nutritional value of the varieties Wilpena and Moonbi, fresh cut on 17th June 2008, Turretfield Research Centre, Rosedale, South Australia.

	Wilpena	Moonbi
Moisture %	88.5	88.4
Dry Matter (DM) %	11.5	11.6
Crude Protein % of DM	25.6	26.6
Neutral Detergent Fibre % of DM	29.6	29.2
Digestibility of DM (DMD) % of DM	89.7	88.2
Digestibility of organic DM (DOMD) % of DM	82.8	81.6
Metabolisable energy (MJ/kg DM)	13.8	13.6

Source: FEEDTEST, Hamilton, Victoria

Table 3: Grazed sulla (8 weeks grazing, sheep removed on August 22nd 2008) – Nutritive value of "Wilpena" sulla sampled on four dates in September 2008, Turretfield Research Centre, Rosedale, South Australia.

	3.09.08	11.09.08	17.09.08	24.09.08
Moisture %	89.6	90.7	88.8	88.4
Dry Matter (DM) %	10.4	9.3	11.2	11.6
Crude Protein % of DM	24.6	22.8	21.1	20.1
Neutral Detergent Fibre % of DM	30.7	30.0	27.7	29.2
Digestibility of DM (DMD) % of DM	80.8	83.8	87.2	85.4
Digestibility of organic (DOMD) % of DM	75.3	77.8	80.7	79.1
Metabolisable Energy (MJ/kg DM)	12.3	12.8	13.4	13.1

Source: FEEDTEST, Hamilton, Victoria

7.5 Grazing summer residues

Sheep will preferentially graze seed pods and any green plants. Researchers at Turretfield Research Centre have found that 75% of seed was eaten by ewe lambs over summer. Very little seed was viable after ingestion and digestion. However, there was no difference in adult plant survival between summer grazed sulla and non-grazed sulla areas. Despite the high seed pod losses, double the number of seedlings regenerated in summer grazed areas compared to non-grazed areas. This is most likely due to the sheep trampling the remaining seed into the soil surface providing better seed soil contact at germination. Extra care will need to be taken when summer grazing on light textured soils sheep will soon undermine plant crowns.

On the left hand side, sheep grazing dry sulla residues, ungrazed on the right hand side (photo by P. Schutz, SARDI)

Close-up of summer grazed sulla residues (photo by P. Schutz, SARDI).

8. Seed Production

8.1 Management

A sulla stand should be closed up early (no later than mid winter) for seed production, this can be done with a first year stand if conditions have been favourable. Seed production under dry land conditions will vary, but can be around 100 kg/ha clean seed in the first year and 250 kg/ha in the second year. Seed yields can be as high as 300 – 500 kg/ha under favourable dry-land conditions.

Caution is needed with grazing or cutting sulla that is intended for seed production as seed yields can be severely affected by frequent or late defoliations (see Figure 6). Maximum seed set was achieved for second year sulla when it was left uncut throughout the growing season in 2008, however had seasonal conditions been more favourable in spring, early cut treatments may have yielded better. (Note, that seed yields were low at Turretfield in 2008 as seasonal conditions became very dry from September onwards). Defoliation was also found to delay flowering in both first and second year stands.

Late grazing in September 2008 in northern NSW was also found to reduce seed yield as there was very little follow-up rain. Monitor the sulla stand for Heliothus and spray if needed, as the insect can reduce seed yields substantially.

It is essential to have plenty of bees at flowering to maximise seed set as sulla is a cross pollinated species. If necessary bring in bee hives. It was noted at Turretfield that bee activity was dramatically reduced during the hot dry spring conditions when the sulla was in full flower, which lead to flower abortion and low seed yields. In addition, the honey made from sulla is very good quality and has a delicate subtle flavour.

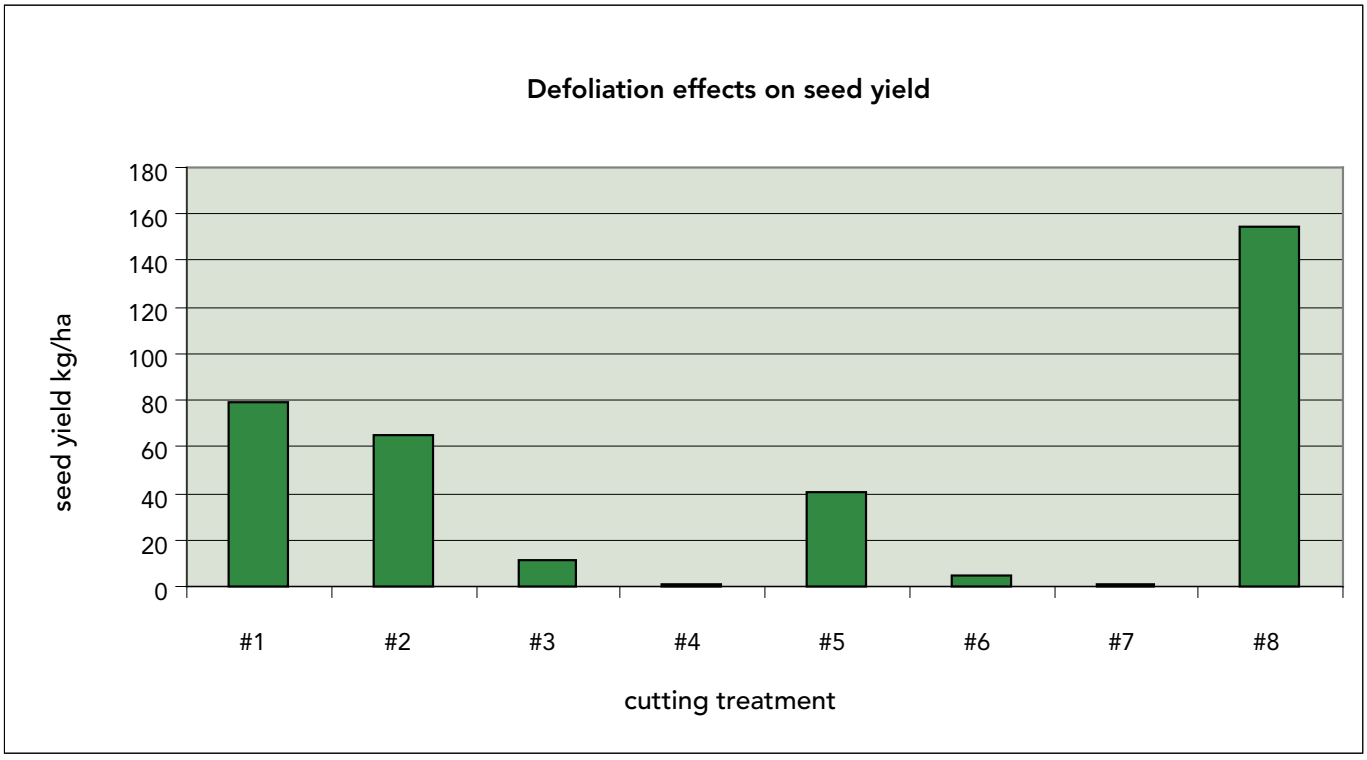

Figure 6: Defoliation effects on sulla seed yield (second year stand), Turretfield Research Centre, Rosedale, South Australia 2008.

Treatment #1 = cut only once 6 weeks after break of season
Treatment #2 = cut only once mid winter (stem elongation)
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Treatment #4 = cut three times in season (#1, #2 & #3)
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Treatment #7 = cut every 30 days
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Flowering generally starts September/October and continues into November and seed matures about 8 weeks later.

8.2 Harvesting

Green stem material at seed maturity is generally not sufficiently dry to allow seed crops to be direct headed and windrowing is strongly recommended. Better results from direct heading can be achieved by waiting for stems to brown. With tall dense stands, mowing the crop can also be difficult and either spraying with diquat to desiccate the stand or grazing in winter to reduce the bulk of herbage at harvesting is recommended. A canola front can be used to pick the material up from the windrow.

Commercial cereal harvesters have been used with normal drum and concave settings for wheat but with a reduced fan speed to 400 rpm to limit loss of seed out the back of the header. A separate dehulling process will be required to remove seed from the pod. Approximately one third of total pod weight is seed.

In New Zealand where grazing is favoured, the recommendation is:

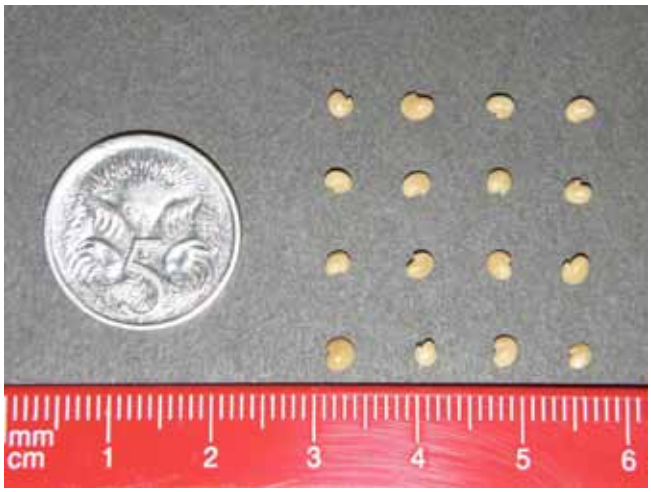
"Grazing should cease before the start of spring and the crop harvested when 50% of the seeds are brown and the other half purplish red. Mow and windrow for a few days or swath to dry the vegetative material before threshing." J.Frame
www.fao.org/ag/AGP/AGPC/doc/GBASE/data/Pf000411.htm

8.3 De-hulling

A specialist dehulling machine is needed to remove the seed from the pod prior to scarification to increase germination. Pods are not hard and woody, but conventional threshers tend to skin the outer layers from the pod without removing the seed, requiring several passes through the machine. More aggressive threshing can easily damage the seed embryo. Pods are difficult to dehull partly because of their flattened structure.

Dry sulla flower head (photo by C. de Koning, SARDI)

Close-up of pods of sulla showing the flattened structure and small spines (photo by P. Schutz, SARDI)



Close-up showing the seed of sulla (photo by P. Schutz, SARDI)

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