A new temperate forage legume with great potential – breeding new cultivars of *Hedysarum*

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Abstract

Hedysarum coronarium (Sulla), *H. carnosum* and *H. flexuosum* have forage potential in the Australian cropping belt, being productive, non-bloating, and adapted to slightly acid to highly alkaline calcareous loam and clay soils. They are likely to benefit the environment by fixing large quantities of N, thus rejuvenating soil fertility and grain crop yield and quality. Sulla and *H. carnosum* are short-term perennial, deep tap rooted plants. Sulla varies in habit from prostrate to erect and is extremely productive (more than 20 t DM/ha in the second year). Lines vary widely in their abilities to set large quantities of seed. *H. carnosum* is an erect though less productive species, but is a heavy seeder. *H. flexuosum* is a productive, erect to semi-erect annual, and is a moderate to heavy seeder. *H. carnosum* flowers early, between 77-98 days, while the other species flower between 98-128 days. All are soft seeded, although they vary for this attribute.

Accessions with high DM and seed production in national evaluations (Qld and SA), and individual Sulla plants surviving dry conditions, root disease, and grazing (Qld) and with high dry matter and seed production attributes (AMGRC rows), are being used to develop synthetics; in Sulla, 18 prostrate and 13 erect synthetics with high DM and seed production, but differing flowering times and levels of hard seed, and two synthetics developed from plants surviving in a sward badly affected by *Rhizoctonia solani* ; and in *H. carnosum* and *H. flexuosum*, four and five synthetics respectively with higher dry matter and seed production and higher hard seed. Seed of these will be bulked for national testing in 2003 and 2004 for cultivar release and, if the breeding program is further resourced, recurrent selection.

Key Words

outcrossing, half sib, recurrent selection

Introduction

There are about 150 species of the temperate legume genus *Hedysarum*. At least 23 species have been introduced into Australia as potentially useful forage plants from 23 countries, predominantly from the Mediterranean basin of southern Europe, the Middle East and northern Africa, but also from China and the USSR. Some species, particularly *H. coronarium* (Sulla) are of significant agricultural importance. Sulla alone is naturalised in 25 countries including Australia (1), although it is confirmed as a native plant in only five countries in northern Africa and southern Europe (2). It is widely used for fodder and hay in Mediterranean Europe (3) and in New Zealand (4).

Following introduction into Australia from their countries of origin, three species, Sulla, *H. carnosum* and *H. flexuosum*, showed promise during characterisation at the Australian Medicago Genetic Resource Centre (AMGRC), SARDI, Adelaide. These were sown in evaluation nurseries throughout Australia in 1998, to identify promising new alternative temperate legumes for more detailed evaluation in the GRDC-funded National Annual Pasture Legume Improvement Project (NAPLIP). There, they were extremely productive and showed particular promise on the alkaline loamy soils of the South Australian (SA) grain

belt and on the alkaline clay and loamy soils of the northern grain belt in Queensland (Qld) and northern New South Wales (NSW).

Cohorts of the three species that included the most promising accessions characterised by AMGRC have been evaluated since 2000 in SA and Qld and, to a limited extent, in northern NSW (5). The hard seed levels at seed set of the accessions sown in those evaluations, their seed softening patterns and the residual hard seed in their seed reserves after the first summer, have also been determined (6). In evaluations in Australia since 1998, there have been no serious disease outbreaks in southern Australia, and red-legged earth mite in SA has been the only damaging insect pest observed. However, the root rotting disease caused by *Rhizoctonia solani* caused severe plant losses in *H. coronarium* at an evaluation site in Qld and in an establishing stand at Tamworth, both on loamy soil.

The need for a breeding program

We are breeding new forage cultivars of all three species. The priority species is Sulla. However, *H. carnosum* and *H. flexuosum,* which have performed well in the subtropics, have also been included.

With Sulla, the primary target is to develop at least one prostrate and one erect cultivar, with high dry matter and seed production, and a range of plant maturities (if more than one cultivar). High dry matter production also implies high nitrogen (N) fixation and soil N accruement. High seed yield, with seed that is easily harvestable and processed, will ensure cheap seed. Prostrate parental germplasm with dense, low crowns and crown buds may confer grazing tolerance. Clones with this attribute have regenerated and survived after heavy grazing at one evaluation site in Qld. An additional target for both prostrate and erect cultivars is a higher level of hard seed, particularly in the development of prostrate cultivars for grazing where regeneration from seedlings may enhance the effective 'life' of the pasture. Breeding for *Rhizoctonia* root rot resistance is a secondary target.

With the other two species, the targets are better dry matter and seed production, and higher levels of hard seed.

General information about the three species

The three species evaluated since 2000 have been described in detail by (7). All are almost exclusively outcrossing and are pollinated by bees.

H coronarium, known alternatively as Sulla, Spanish or Italian sanfoin, French honeysuckle and Sulla sweet vetch, is a short-lived, tap rooted, herbaceous perennial adapted to a mildly acid to alkaline soil pH range, but particularly to calcareous soils. It is widely sown in Sicily for hay production and two cultivars have been released in New Zealand. There is a wide range of habit form, from prostrate types that may be better suited to grazing, to the semi-erect and erect types that may be better suited for hay or green manure. Erect types grow to 1.6 m tall. Sulla has a high content of condensed tannins that entrap proteins and thus bypass rumen degradation. These also convey non-bloating and anti-helminthic attributes. Sulla is dormant during the summer but can make significant growth in the autumn and very high levels of production in the spring (5). Among 79 lines sown in June 2000 at Oakey, Qld, their time to flower varied from 98-128 days and 9 lines did not flower at all. Their seed production was variable, irrespective of time to flower, though lines flowering later than 109 days produced only small quantities of seed (D. Lloyd, unpublished data). Nevertheless, the persistence of Sulla lines that have produced large quantities of seed can be enhanced by large seedling recruitment in the autumn, with > 4000/m^2 measured in evaluation trials in SA (de Koning, pers. comm.). Sulla is generally not hard seeded although hard seed proportions at seed set varied from 19.6% to 79.2%, and after softening for one summer from 1.1% to 32.4% (8).

Hedysarum carnosum is also an herbaceous, tap rooted, short-lived perennial with a greater tolerance to climatic aridity and soil than Sulla (7). It is erect in habit and grows more than 1 m tall. It is not as productive as Sulla and there is no record of its commercial use. It is earlier flowering than Sulla. Of the

five lines evaluated, four flowered 77 days after sowing and the other after 98 days. All lines produced large quantities of seed and have recruited large numbers of seedlings. *H. carnosum* is relatively soft seeded though more hard seeded than Sulla. Hard seed proportions at seed set varied from 30.7% to 79.3%, and after softening for one summer from 20.1% to 58.1% (8).

Hedysarum flexuosum is an herbaceous annual, capable of growing 1m tall. Lines vary in habit from erect to semi-erect. It is productive, but appears to make less growth in the winter in southern Australia than Sulla (de Koning, pers.comm.). Eight of the 10 lines evaluated flowered between 109-116 days after sowing, with the remaining two lines flowering after 122 and 128 days, and all lines produced large quantities of seed (Lloyd, unpublished data). *H. flexuosum* is also relatively soft seeded with hard seed varying from 54.1% to 83.2% at seed set, and from 16.7% to 39.8% after the first summer (8).

Breeding Methodology and Discussion

The breeding program is being carried out with limited resources and is the first phase of a larger program for which additional resources are being sought. We are conducting half-sib crosses of elite lines to provide the basis for recurrent mass selection in an extended program. If the program is attenuated, elite crosses will be progressed to cultivars and will be commercialised.

Synthetics developed after 1st year evaluation

In 2001, following the evaluation of dry matter and seed production at two sites in SA and three sites in Qld, and after the determination of hard seed characteristics, elite parent lines of all three species were selected for crossing.

Twenty-five synthetics of Sulla have been developed. Fifteen prostrate (grazing) synthetics were based on combinations of six lines with generally high dry matter and seed production. Seven of these targeted higher herbage production, four targeted a prostrate habit and four targeted higher hard seed. Ten erect (fodder) synthetics were based on combinations of seven lines. Four of these targeted high seed production, three targeted high herbage production and three targeted higher hard seed.

Three synthetics of *H. carnosum* were developed for combinations of herbage and seed yield and higher hard seed, and five synthetics of *H. flexuosum* were developed, three focused on herbage and two on seed production.

Key attributes of the elite parent breeder lines are summarised in Table 1.

Table 1: Key attributes in the selection of elite parent lines used in the first crosses in 2001

Species	Line	Origin	Erect habit	S.erect habit	Prostrate habit	Early fl'ring	Late fl'ring	DM Yield	Seed Yield	High H'seed
Sulla										
Prostrate	HS09	Sicily		√				√	√	√
	HS26	Tunisia			√	√				
	HS27	Tunisia			√				√	

	HS29	Italy			√						√
	HS30	Italy		√					√	√	
	HS34	Tunisia			√	√				√	
Erect	HS13	Bulgaria	√						√	√	
	HS19	Morocco		√						√	
	HS20	Morocco	√						√		
	HS30	Italy		√					√	√	
	HS31	Tunisia	√				√				
	HS32	Sicily		√							√
	HS33	Tunisia			√					√	√
Carnosum											
	HC01	Tunisia	√							√	
	HC02	Tunisia	√								√
	HC05	Tunisia	√						√	√	
Flexuosum											
	HF04	Morocco		√					√		
	HF06	Morocco		√						√	
	HF07	Tunisia			√					√	
	HF08	Morocco	√						√		

Basic seed from the AMGRC was used for these crosses. Established plants were placed in crossing cages at the SARDI Waite Campus in carefully selected combinations, and bees were introduced to the

cages at flowering time during the spring to produce F_1 generation seed in 2001. In 2002, established plants from the F1 generation seed of each synthetic were again placed in crossing cages as in 2001, to produce F_2 generation seed for national testing in 2003.

Sulla synthetics developed after 2nd year evaluation

In 2002, results from the SA, Qld and northern NSW evaluations were reviewed and six new Sulla synthetics have been developed, three fodder (erect) types and three grazing (prostrate) types.

The fodder type synthetics were based on five lines:

- HS30, high forage and seed production in 1st year evaluations in Qld and SA.
- HS08 and HS22, very high herbage and seed production in 2nd year evaluations in SA.
- HS36 and HS38, very high herbage and seed production in new sowings in SA.

The grazing types were based on three elite lines identified in new AMGRC sowings in 2001:

- HS36, used particularly in these synthetics as a source of early flowering.
- HS35 and HS37, high herbage production.

These were grown in crossing cages in 2002 to produce F_1 generation seed and this F_1 seed will be sown similarly in 2003 to produce F_2 generation seed for national testing in 2004.

When severe plant losses in Sulla due to *Rhizoctonia* root rot were measured at one site in Qld in spring 2001, the 180 surviving plants that may possess resistance to the disease were sown as single clones in pots in Toowoomba in spring 2001and characterised. Following *ad lib* pollination of flowering clones by bees, F_1 generation seed was collected from each clone. Based on the morphology of the maternal parents, two synthetics, one 'prostrate' and one 'erect', were created *viz*. 'Grazing' based on 67 maternal clones from 16 lines, and 'Fodder' based on 38 maternal clones from 16 lines. In 2002, the seed from each was established in pots at the SARDI Waite Campus and placed in crossing cages to produce F_2 generation seed for national testing in 2003.

Conclusions

F2 generation synthetics of *H. coronarium, H. carnosum* and *H. flexuosum*. will be evaluated nationally in 2003/04 and 2004/05 and cultivars released and commercialised. If a full-scale breeding program is resourced, recurrent selection for the attributes described previously from elite plants at those evaluation sites, and further crossing, will be carried out to refine the germplasm and then release a new generation of superior cultivars.

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