Hairy canary clover: a case study for integrating semi-herbaceous forage plants into agricultural systems

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Abstract

Novel perennial forages with agricultural potential include species that can be best described as semi-herbaceous. Plants in this category produce woody stems, but are neither fully herbaceous nor woody shrubs; instead they lie somewhere on the continuum between these plant forms. These plants are not currently used in Australian agriculture and we have little understanding of their agronomic potential and role in agricultural systems. Study of the attributes of one semi-herbaceous species, hairy canary clover (*Dorycnium hirsutum*), should provide insights relevant to similar species. Major limitations exhibited by hairy canary clover are poor seedling vigour and establishment difficulties, low growth rate relative to lucerne, accumulation of woody stems and poor digestibility of edible components. Nonetheless, hairy canary clover retains leaves and may be suitable to provide drought fodder in lower rainfall environments on acid soils, where lucerne productivity is low. It is unlikely semi-herbaceous species will be used where sown herbaceous pastures are well adapted. Tolerance of conditions that limit current forage options, easy and cheap establishment, and favourable forage quality are important if semi-herbaceous species are to be successful. High cost establishment would prohibit the use of short-term pasture phases (≤ 3 years), but permanent pastures or long-term rotations (> 4 years) could be viable for long-lived plants. The ability to provide feed when other forage sources are of poor quality and in limited supply would be particularly valuable. In addition, semi-herbaceous forage plants that provide additional benefits in areas such as water and nutrient management, animal health or weed control would be attractive.

Keywords.

Perennial pastures l, forage shrubs, agronomic traits, *Dorycnium*

Introduction

Integration of perennial forage plants into agricultural systems may overcome a number of sustainability constraints such as soil erosion, soil structural decline, soil acidification and dryland salinity (Cransberg and McFarlane, 1994). For example, summer-active deep-rooted pastures can reduce the accumulation and leaching of nitrate associated with sub-soil acidification (Ridley *et al*. 1990). These pastures can also increase water use by extracting water from deep soil layers, thus creating a large dry soil buffer that reduces the frequency and magnitude of recharge into groundwater tables (Ward *et al*. 2006). A number of perennial plants that currently deliver these benefits are also economically attractive for farmers and are used as forage species in agricultural regions of southern Australia. Nonetheless, a greater selection of perennial forages is required to satisfy the range of climatic and edaphic environments and production systems in southern Australia. A range of novel undomesticated perennial plants is currently being evaluated for potential as forage species in southern Australia.

Dorycnium hirsutum*: an example of a semi-herbaceous plant*

Dorycnium hirsutum (L.) Ser. (hairy canary clover) is representative of a group of plants that are different from forage species currently used in Australia. While plants are often defined as herbaceous or woody, in fact there is a continuum of forms between these two extremes (Figure 1). Semi-herbaceous plants, like *D. hirsutum*, fall somewhere between shrubs and herbaceous plants because they accumulate some woody stem. However, the stem material is not an integral and long-term part of the plants' structure, as it is in shrubs. Among the novel perennial forage species under evaluation a number of species fit this general category (Table 1). Recent studies of *D. hirsutum* provide an indication of key morphological and agronomic traits that will influence the potential role of these similar species in current or future agricultural systems.

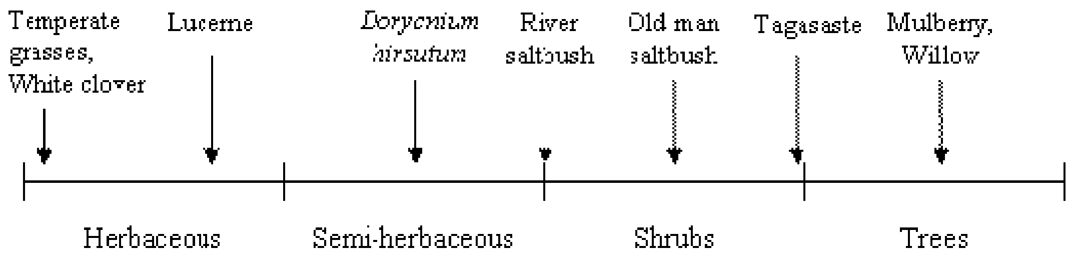

Figure 1. Variation in plant form between selected forage species on a continuum between fully herbaceous and woody trees.

Table 1. Potential forage species that could be described as semi-herbaceous.

Scientific name	Common name
Exotic legumes	
Bituminaria bituminosa	Arabian scurfpea
Lespedeza juncea	Japanese Bush Clover
Dorycnium hirsutum	Hairy canary clover
Dorycnium pentaphyllum	Prostrate canary clover, scarillo
Dorycnium rectum	Erect canary clover
Coronilla valentina	Shrubby Crown Vetch
Ononis spinosa	Spiny Restharrow
Desmanthus acuminatus	
Desmanthus virgatus	
Native legumes	
Cullen australasicum	Scurf peas

Cullen leucanthum	
Kennedia prostrata	Running Postman, Scarlet Coral Pea
Kennedia prorepens	Desert Kennedia
Swainsona colutoides	Bladder vetch
Other dicot species	
Atriplex amnicola	River saltbush

Characteristics and performance of Dorycnium hirsutum

Biomass production from *D. hirsutum* is generally lower than lucerne (Bell *et al*. 2006b; Douglas and Foote 1994), but in situations where lucerne is poorly adapted productivity can be comparable (Wills *et al*. 1989). However, *D. hirsutum* can accumulate up to 70% of plant biomass as woody stem if left ungrazed (Bell *et al*. 2006a). Managed in this way much plant biomass may not be acceptable to livestock. Futhermore, forage quality appears to be a major limitation of *D. hirsutum*, with dry matter digestibility of edible shoot often < 55% (Bell 2006a; Davies and Lane 2003). The reasons for low forage digestibility in *D. hirsutum* are unclear but could be related to high concentrations of condensed tannins (19% DM) (Terrill *et al*. 1992), which can bind to protein and reduce digestion in the rumen. Its low forage quality means that the best opportunity for *D. hirsutum* utilisation is when other available pastures are of low quality and quantity. *D. hirsutum* has demonstrated the ability to accumulate DM and retain green leaves during drought periods and thus may be suitable to provide forage to fill gaps in feed availability from other sources.

Dorycnium hirsutum has demonstrated drought tolerance and is able to persist in low rainfall environments. Lucerne is currently the best perennial forage option in low rainfall zones, but its performance is poor on acid and waterlogged soils. While some other less drought tolerant perennial legumes have higher tolerance of soil acidity (e.g. *Lotus pedunculatus*), moderate tolerance of aluminium in *D. hirsutum* suggest it is also suitable for acid soils (Wheeler and Dodd 1995). Thus, *D. hirsutum* may provide an alternative to lucerne on acid soils in low rainfall environments.

Slow early growth of *D. hirsutum* appears to be a major limitation. Plants grown at field sites in the Western Australian wheatbelt rarely achieved a main stem length of >12 cm in the first growing season (Bell *et al.* 2005). Similarly, low seedling vigour has been documented in New Zealand (Douglas and Foote, 1994). Initially it was thought that slow seedling growth was a result of large allocation of resources to roots. However, a glasshouse study demonstrated that root growth was no greater than lucerne and slower seedling growth was due to a longer period between germination and emergence and a slower relative growth rate (Bell 2005b). The slow early growth of *D. hirsutum* means seedlings are prone to competition from weeds during establishment and an effective weed management strategy is required. Delaying sowing until early July (mid winter) to allow most germinating weeds to be removed did not reduce seedling germination and survival of *D. hirsutum*, but sowing in spring did reduce the number of seedlings that survived (Bell *et al.* 2005). Nonetheless slow growth of *D. hirsutum* during the first year also means that grazing is rarely possible until after 2 growing seasons (Sheppard and Douglas 1984). Establishment difficulties would preclude its use in the short phase rotations (< 4 years) commonly used for lucerne. Longer-term rotations or permanent pastures, which spread the cost of establishment over a longer period, are therefore desirable for *D. hirsutum*.

Once established *D. hirsutum* plants are tolerant of heavy grazing. However, they don't appear to withstand frequent high intensity defoliation. When plants were cut at 8 week intervals plant regrowth declined with each cut and plant death occurred in plants cut at lower heights (Bell *et al*. 2006a). This suggests that *D. hirsutum* requires a longer interval between grazing events. However, a longer interval between grazing may result in a greater proportion of low quality or inedible woody stem.

D. hirsutum has demonstrated the ability to use similar amounts of water as lucerne. Soil under *D. hirsutum*-based pastures at the end of summer was drier than annual pastures by 8-23 mm in the year of sowing, 43-57 mm in year 2 and 81 mm in year 3. This coincided with an increasing depth of water extraction to 1.0 m, 1.8 m and 2.2 m (Bell *et al*. 2006b). These results suggest that *D. hirsutum* plants produce an extensive root system and could be used in mixtures with annuals to maintain pasture productivity while also providing water use benefits.

Commonalities between Dorycnium hirsutum *and other semi-herbaceous plants*

While the array of agronomic traits of other semi-herbaceous plants will obviously differ from *D. hirsutum* to some degree, we anticipate that a number of characteristics will be common. First, like forage shrubs, woodiness will generally be associated with lower productivity than herbaceous forages because of allocation of resources to woody structures and thus all biomass will not be edible to livestock. Secondly, to persist they will require special grazing management to control the accumulation of woody components and to maximise edible forage production. Thirdly, because of a more conservative growth strategy, semi-herbaceous plants will reduce leaf turnover and have a greater capacity to retain leaves during periods of stress. To protect these leaves from pathogens, insects and herbivores these plants are likely to contain anti-nutritional compounds such as condensed tannins or toxins that will impact on their value for livestock. Finally, semi-herbaceous plants will possess extensive enduring root systems that enable them to survive and maintain above-ground biomass during periods of drought.

General role of semi-herbaceous plants and key agronomic traits

Unless novel semi-herbaceous species can match the productivity of current perennial pasture options their role is limited to situations where the performance of herbaceous options is constrained. For example, the forage shrubs tagasaste (Cytisus proliferus) and saltbush (Atriplex spp.) are exploited on deep infertile sands and saline soils, respectively. Thus, tolerance of stresses that limit the productivity and survival of herbaceous plants will be a vital attribute of successful semi-herbaceous plants.

Low forage quality and the presence of anti-nutritional compounds may greatly reduce the grazing value of semi-herbaceous shrubs. However, specific management or breeding and selection may reduce impacts on animal health and forage palatability and quality. While low forage quality may limit the value of *D. hirsutum* for livestock, the capacity to deliver forage when the availability of other sources is limited will reduce the cost of supplementary feeding and could increase farm livestock carrying capacity. The ability of semi-herbaceous plants to retain leaves under stress is a valuable trait that might be exploited for this purpose.

Should other semi-herbaceous plants produce deep root systems and maintain leaf area in a similar way to *D. hirsutum* then they could provide important water use benefits. A low density of semi-herbaceous plants in mixtures with annuals seems to be a likely system that could increase water use and maintain productivity.

Easy, low cost and reliable establishment and easy subsequent removal of plants is a vital requirement of plants destined for use in short-term rotations with crops. If establishment is costly then plants will be best suited to longer rotations or permanent pastures. However, permanent pastures will only be adopted where crop profitability is low. Long-term rotations of perennial pastures with crops will need to create a large enough soil buffer to protect a number of years of crops from drainage.

In addition to the strategic role of semi-herbaceous plants in farming systems, there are a range of other considerations, such as nitrogen and nutrient dynamics, forage palatability, animal health, weed management issues and opportunities, herbicide tolerance, diseases and pests, that will influence how they are used in agricultural systems.

Conclusion

Research into the suitability of *D. hirsutum* as a perennial forage has shown a number of benefits and limitations of this species and it remains uncertain whether it will be commercially useful. The research has also highlighted issues likely to be important in assessing the potential of other semi-herbaceous species and has helped discern their likely role in the context of future farming systems.

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