Management of annual legume pastures

C.W. Thorn

Officer in Charge
Western Australian Department of Agriculture,
Moora, Western Australia 6510

Introduction

The use of self regenerating annual legume pasture species developed during the 1950s in southern Australia. Today some 27 million hectares have been sown to improved pasture species of the Trifolium and Medicago genera. The Introduction of these pasture species into legume-cereal rotations increased the stock carrying capacity, cereal yields and gave a more stable farm income. The value of incremental soil nitrogen from grazed annual legume pastures has been estimated at $800 million per year (Carter 1978).

In recent years there has been a resurgence in the use of annual medic. With the development of burr medics (Medicago polymorpha) in Western Australia an estimated 480,000 hectares has been sown since 1983. In South Australia, Victoria and New South Wales the development of bluegreen aphid (Acyrthosiphon kondoi) resistant Medicago truncatula and M. littoralis) cultivars has increased the **use** of medics in the traditional wheat and sheep areas.

The further development of other pasture legume species like M. murex, M. aculeata, M. tornata, T. balansae, T. resupinatum and O. compressus will increase the role of annual legumes in cereal-pasture rotations in southern Australia. Gillespie (1988) estimated that 3.4 million hectares of soils in southern Australia were suited to murex medic.

The development of new "niche" specific pasture legume species will necessitate the continual refinement of management techniques.

This paper reviews the various management factors which govern the production and persistence of annual legume pastures in a cereal-legume rotational system as practiced in southern Australia. The influence of grazing management, rotation, establishment, fertilizer, weed control and insect control will be considered.

Establishment

The establishment of successful legume pastures depends upon seasonal conditions, paddock choice, weed control, sowing method, time of sowing, correct varietal choice and insect control.

The main objective in re-establishing legume pastures is to achieve a high initial seed set to provide the base for self regeneration in future years.

Seasonal Conditions

Seasonal variation is the major factor governing the success or failure of establishing pasture species. Many farmers re-establish medic pastures by sowing on the first rains; in some years a lack of sufficient follow up rains results in poor establishment.

Species and Cultivar Selection

Details of species and cultivar and their soil type adaption has been described by Gillespie (1989).

Time of Planting

Time of planting of annual pasture species has a large effect upon the successful re-establishment of pastures. Thorn et al. (1988) found that delaying the sowing of burr medic resulted in 8.4 kg/ha of seed production lost for every days delay in sowing after the beginning of May. Little information for other annual pasture legume species is available.

Seeding Rate

Plant density governs early winter pasture production. Sowing rates of pasture legumes range from 2-10 kg/ha. The optimum seeding rate in terms of initial seed production is around 8 kg/ha for subterranean clover and medic cultivars. The sowing rate of smaller seeded pasture species is generally lower. Serradella is usually sown at 2-4 kg/ha, as is T. balansae and T. resupinatum.

Sowing Methods

Annual pasture legume seeds should be shallow seeded. Carter and Challis (1987) found that as depth of sowing increased, emergence and seedling dry weight decreased. The effect was more pronounced on loamy than sandy soils.

Bolland (1985) found that the most successful method of establishing subterranean clover on sandplain soils was by dry sowing into a weed free cereal stubble.

The usual method of sowing a pasture is to use a "knock down" herbicide and direct drill the seed near the break of the season (Ewing 1989). Direct drilling without weed control has not been successful.

Sowing pastures under a cereal crop is not a recommended practice in Western Australia, but is a common practice in New South Wales where the last cereal crop in a 3:3 pasture:crop rotation is undersown. In Western Australia both under sown subterranean clover and burr medic can reduce cereal yields in some cases by 5-25% and the seed yield of the legume reduced by at least 50% (Poole and Gartrell 1970; Ewing 1989).

Bolland (1986) found that sowing pod segments of serradella under a cereal crop at 20 kg/ha gave an equivalent regeneration in the second year of 4 kg/ha of naked seed. Serradella established at around 1000 plants/m2.

The use of an oat cover crop when establishing a pasture provides valuable early feed as long as the oats are grazed out within 8-10 weeks after sowing. The economics of such sowing techniques have not been researched.

Grazing management

Grazing management factors such as stocking rate and deferred grazing markedly influence the dry matter and seed production of legume pastures.

Stocking Rate

Pasture dry matter production and growth rate are maximized by maintaining near optimum leaf area index (LAI). In a grazed medic pasture optimum LAI is rarely achieved during the autumn and winter. The aim of early season grazing management should be to encourage rapid leaf development.

The removal of herbage by the grazing animal reduces pasture growth rate and a relationship between stocking rate and pasture dry matter production and growth rate exists.

Thorn et al. (1988) found that on a burr medic pasture total dry matter production was reduced by 780 kg/ha per additional wether (Figure 1). This is considerably higher than that recorded on subterranean clover of 160-350 kg/ha/DSE (Thorn 1989, Dunlop et al. 1984).

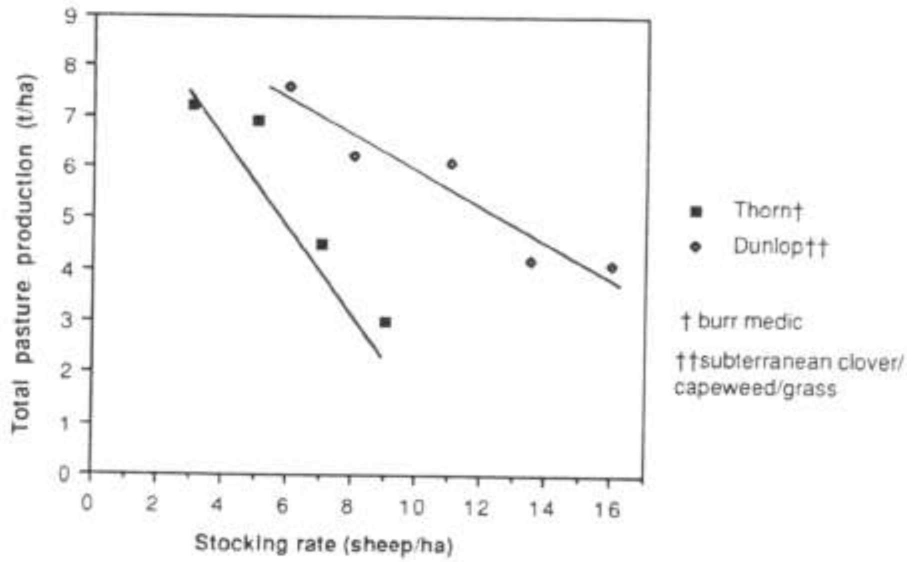

Figure 1. The effect of stocking rate on total pasture production for the year

Little information is available on individual species response to grazing. The comparison of 5 pasture species for dry matter and seed production under artificial defoliation showed that the total dry matter production of Circle Valley (M. polymorpha), a murex line (M. murex) 5320 and serradella (0. compressus DP6) were more severely reduced by defoliation throughout the growing season than either Beenong cupped clover (T. cherleri) or Daliak subterranean clover (Figure 2).

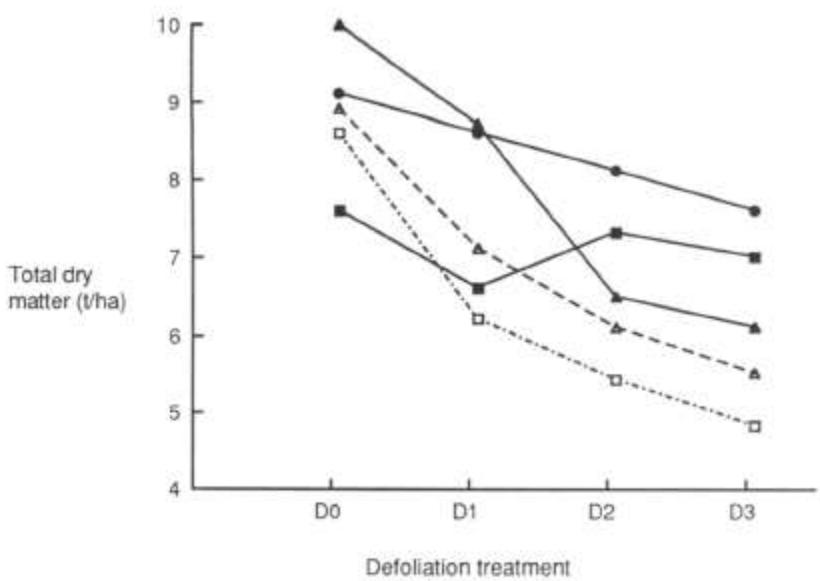

Figure 2. Effect of defoliation on the total dry matter (t/ha) of five pasture species of similar maturity. (●) Beenong (T. cherleri), (▲) murex 5320 (M. murex), (Δ) Circle Valley (M. polymorpha), (■) Daliak (T. subterraneum), (□) DP6 Serradella (O. compressus).
DO - Undefoliated.
D1 - Defoliated fortnightly (2.5 cm) 54-105 days.
D2 - Defoliated fortnightly (2.5 cm) 54-123 days.
D3 - Defoliated fortnightly (2.5 cm) 54-139 days.

In the defoliation experiment the pattern of dry matter removal suggested that the greater height of Circle Valley contributed to a higher removal of dry matter throughout winter. It suggests that burr medic is more accessible in winter and provides more available feed to grazing sheep. Whether this translates into the grazing system is difficult to determine. In an adjacent grazing trial Circle Valley had the highest growth rates in winter (19/6-16/8). There was little difference between murex, cupped clover and subterranean clover (Table 1).

Table 1. Winter growth rate (kg/ha/day) of four pasture species under grazed (10 sheep/ha) and ungrazed conditions. Source: (Thorn; unpublished data)

	Pasture growth rate (kg/ha/day)					
	18/7-31/7		1/8-17/8		Mean	
	not grazed	grazed	not grazed	grazed	not grazed	grazed
Circle Valley	54	23	71	35	62	27
Beenong	23	-	18	3	20	-
Daliak	15	4	21	3	18	4
Murex 5320	8	8	29	6	18	7

The dry matter production response of pastures species to grazing will govern the long term stocking rate and long term persistence of the species. This raises questions about the grazing management strategies to be adopted in pastures swards comprising a mixture of species like murex medic/subterranean clover and burr medic/subterranean clover. The greater accessibility of medics in autumn and winter may make them more likely to be grazed out in species mixtures if the grazing pressure is high. Very few studies on the long term production of species mixtures is currently available. The understanding of the behaviour of species mixtures is becoming increasingly important as producers mix M. murex and M. polymorpha with subterranean clover on soils with a slightly acid pH; use of lime on pastures to increase soil pH is more widely adopted and as further improvements are made in the selection of acid tolerant Rhizobium meliloti.

Seed Production

Rossiter (1977) concluded that the seed producing capacity of subterranean clover was the most important factor governing persistence. Seed producing capacity is reduced by water stress during flowering (Andrews et al. 1977) and the restriction of burr burial on hard setting soils in dry years (Taylor and Rossiter 1969). The maturity of cultivars also influences seed production capacity (SPC) in a given environment. Early maturing cultivars have high seed producing capacity in a wide range of environments while late maturing cultivars have high SPC in high rainfall areas only. The comparison of the seed production of three burr medic lines Circle Valley (100 days to flower), Santiago (90 days to flower) and Serena (80 days to flower) against the mean site yield of a range of burr medic lines showed that Santiago had a high SPC in both high and low rainfall environments and in good and bad seasons compared to Circle Valley whose high SPC was restricted to high rainfall and good seasonal conditions (Thorn unpublished data).

Grazing before flowering increases subterranean clover seed production (Rossiter 1966; Collins 1978). This is also the case for M. murex, however the seed production of burr medic (M. polymorpha) is reduced by grazing (Thorn 1988; Gillespie 1988). A link exists between stocking rate and long term pasture production and persistence through its effect on pasture growth and seed set. Reduced growth induced by a high stocking rate leading up to flowering results in less seed set. This was illustrated experimentally at Gnowangerup in 1985 where each extra sheep carried reduced medic seed production by 52 kg/ha (Thorn et al. 1988).

In annual legume pasture species trials in Western Australia, the cultivar Santiago appears to be able to produce more seed under grazing than either Circle Valley or Serena (Revell and Ewing, 1988). This raises the question of the scope for further selection within pasture species for greater tolerance to grazing. Selection for more prostrate types, lines with a greater ability to branch and lines with a greater ability to recover from severe grazing may be beneficial.

Grazing during the summer and autumn also reduces the seed bank of annual pasture species. Sheep grazing Circle Valley medic at 5 sheep/ha were found to consume 500 g/head/day of pod from late October to early May (Thorn et al. 1988). Gillespie (1989) found that sheep grazing Zodiac murex medic over summer reduced the seed bank from 690 kg/ha in December to 27 kg/ha at the end of March. This dramatic reduction in the murex seed reserves raises serious questions about the ability of some pasture species to withstand hard grazing over summer. T. hirtum and T. cherleri have failed to persist due to the reduction of the seed bank by grazing sheep in spring and summer.

The importance of seed passage through the animal in annual legumes is poorly understood. Pen trials have shown that 25% of ingested M. polymorpha cv Circle Valley burr is passed in the faeces. Larger seeded medics like M. truncatula and M. murex have only limited seed passage (< 5%).

Factors such as pod size, seed/pod ratio and the effect of mature forage on seed digestion requires further evaluation. The average size of seed passed by sheep grazing Circle Valley was 2.9 mg compared to the average seed size in the field of 3.5 mg. This suggest that there may be a critical size, weight or shape of seed governing the passage of seed. It is not uncommon to observe that between 12-15% of faecal weight was made up of seed, with between 10-13 seeds/pellet.

The importance of seed passage in influencing the persistence of a pasture species is unknown, however, it is a factor which should not be ignored in some species.

Deferred Grazing

Once established, most pastures can be grazed from the break of season. If grazing is deferred for longer than 6 weeks then weed competition can seriously reduce the production of the legume component. This effect usually continues through until seed production. Bolland (pers com) stated that early grazing of serradella (O. compressus) is essential if a serradella stand is to be maintained as its prostrate growth habit and slow winter growth make it susceptible to weed competition.

The most opportune time to defer grazing in newly sown pastures is in spring to allow adequate seed production. The cost of spring deferment is low due to the abundance of available pasture at this time.

Once seed reserves have been built up pastures will not require deferment in either autumn or spring. However if overgrazing and cropping limit seed production for three to four years than seed reserves will fall and careful pasture management will be required to restore the seed reserves.

Cropping and pasture legume production

Annual legume based pastures are grown in rotation with cereal crops throughout most of the medium and low rainfall areas of southern Australia. Legume based pastures provide valuable nitrogen for the cereal, act as a break crop for cereal diseases and help improve soil structure.

Rotation, cultivation method, crop husbandry, stubble management, pasture species and season all affect the quantity of seed available for regeneration (Nicholas 1989).

Rotation

In the past 30 years we have seen cyclical patterns of increased pasture sowings and cereal cropping. In the 1960s the trend was towards sowing more pasture, while in the 1970s - early 1980s cropping returned to favour, and in recent years a return to greater interest in pastures. The move to increased cropping throughout the 1970s and early eighties reduced the seed bank of many pastures to low levels.

Carter (1982) found that of 35 stubble paddocks in South Australia, sampled in March 1981, only 20% had satisfactory seed reserves (Table 2).

Table 2. Medic seed reserves in stubble paddocks (after Carter 1982)

Status	No. sites	March seed reserves (kg/ha)	% medic August 1981	Classification
1	14	9	8	extremely poor
2	3	33	32	very poor
3	5	71	35	poor
4	6	136	54	fair
5	3	244	59	good
6	4	321	72	very good

Nicholas (1989) showed a large reduction in both subterranean clover and medic seed banks associated with a cereal crop (Table 3).

Table 3. Legume seed reserves (kg/ha) in summer (after Nicholas 1989)

A. Subterranean clover

Location	Year					
	1983	1984	1985	1986	1987	1988
Wandering	410	510	550	330	480	240
Arthur River	13	8	3*	440#	650	730
Arthur River	110	80	300	40*	6*	550#

B. Burr medic (M. polymorpha)

Rotation Pasture:crop	Year (Pingrup 350mm)				
	1984	1985	1986	1987	1988
1:1	703#	590*	283	71*	260
2:1	703#	512	160*	253	273
2:2	703#	512	175*	96*	289

Rotation Pasture:crop	1984	1985	1986	1987	1988
		Year (Gnowangerup 400 mm)			
1:1	464#	257*	562	169*	321
2:1	464#	286	92*	82	200
2:2	464#	127	132*	51*	151

Resown pasture. * Crop.

The data alone show the value of reseeding a pasture with a low seed reserve to greatly increase the following year's seed reserves.

Fundamental to any discussion of the effect of crop rotations on pasture persistence is the understanding of hardseededness. Hardseededness or seed impermeability regulates germination as it prevents viable seed from imbibing water and germinating. Annual pasture legumes widely vary in their levels of hardseed and hence ability to persist through short pasture-crop rotations and drought years. Other factors which influence the level of hardseed are environmental conditions, stubble cover, depth of seed burial and seed history.

In general the level of hardseededness for pasture species in order of decreasing level of hardseed is M. polymorpha > M. littoralis > M. truncatula > M. murex > T. cherleri > T. subterraneum > O. compressus.

There is large degree of genetic variability in the level of hard seededness within annual legume pasture species (Table 4).

Table 4. Percentage hardseed of a range of pasture species and lines within a species as measured in late April (29.4.84) (Source Revell and Thorn 1984 Experimental Summaries)

Species	Line	Hardseed %
M. polymorpha	Circle Valley	90
	4991	84
	793-2/4	81
M. murex	Zodiac	88
	CD 64.4.1	74
	CD 80.3	51
M. truncatula	Cyprus	88
T. subterraneum	8B40.2.1.1	80
	Dalkeith	73
	Northam	54
	Daliak	50
T. cherleri	Beenong	85

The higher level of hardseed in medics allows them to be cropped in shorter and more frequently cropped rotations than either subterranean clover or serradella. An objective within the National Medic Improvement Programme is to select for lower levels of hardseed in M. truncatula lines, while the selection policy in the National Subterranean Clover Breeding Programme has been to select lines with higher levels of hardseed, particularly for the medium and low rainfall areas.

Crawford and Nankivell (1989) compared the persistence of M. rugosa cv Paragosa, M. truncatula cv Cyprus and Jemalong and M. scutellata cv Robinson in three rotations; permanent pasture, pasture-barley and pasture-fallow-wheat-barley. Annual re-establishment was greatest for all cultivars under permanent pasture than either of the two other rotational systems. The seed reserves of Paragosa were exhausted by the third year, while Cyprus and Jemalong maintained adequate seed reserves to enable good plant establishment in the sixth year. Cultivation and subsequent pod burial in the two cropping rotations preserved seed reserves longer than the permanent pasture system.

Taylor and Ewing (1988) found that after 5 years Serena burr medic still had seed reserves equivalent to 20% of the initial seed population, while the hardseed reserves of Geraldton clover were less than 5% of the initial seed population by the end of the second summer.

Heida and Jones (1988) measured the seed reserves of M. truncatula and M. scutellata in south-east Queensland. Seed reserves were higher under permanent pasture, followed by a ungrazed ley, a three year pasture:1 year wheat rotation and then a 2 year pasture:2 year wheat rotation.

Cultivation

Cultivation technique governs the distribution of seed throughout the soil profile. Quigley et al. (1987) found that between 60-95% of medic seed was found in the top 5 cm. He stated that deep tillage may bury seed to 10 cm.

Taylor (1985) found that with no tillage all clover seed was in the top 2 cm. With minimum tillage (one pass with a scarifier) approximately 55% of seed was left in the top 2 cm, 40% in the 2-6 cm depth and 5% at greater than 6 cm. Conventional tillage of a ploughing and two scarifications buried 65% of the seed below 2 cm, with 20% of seed buried at greater than 6 cm.

As the rate of softening in medic seeds is less affected by depth of burial than clover, burial is of less importance in maintaining medic seed reserves. Medic pastures are therefore well suited to minimum tillage cropping systems (Taylor and Ewing, 1988)

Autumn cultivation to bury burr medic pod enhances regeneration (Table 5). Gillespie (1988) found that an autumn cultivation increased plant density of subterranean clover by 13%, murex medic by 40% and burr medic by 91%. Autumn cultivation also increases the density of ryegrass which will then compete with the medic.

Table 5. Effect of autumn cultivation on Serena burr medic regeneration

	Regeneration of medic (plants/m^2)	
	Site 1	Site 2
Untreated	3,004	3,909
Cultivation after false break (4.3.86)	4,643	4,898
Cultivation before main break (17.5.86)	4,665	4,894
Cultivation after main break (19.5.86)	1,643	1,004

Other Effects Of Cereal Crops On Pasture Establishment Rotations also affect seed reserves in other less obvious ways:

- The use of herbicides prevents pasture seed production under the crop and reduces grass weed burdens which may result in less competition to pasture legumes from grasses in the following year.
- Successive crops have a greater detrimental effect on seed reserves of subterranean clover than medics.
- Poor seasons in the pasture years between crops, coupled with cropping, compound the reduction of the seed reserves. A similar situation exists if excessive grazing in the pasture year between crops in a 1:1 rotation does not allow adequate seed production. This situation is more significant in subterranean clover than medic pastures (Nicholas 1989).
- Successive cereal crops may reduce the population of Rhizobium particularly R. meliloti on acid soils. Little information is available in the literature on this effect.
- Cereal straw density is also known to affect medic plant density. Higher levels of straw reduce medic regeneration (Reeves 1987). A 63% reduction in medic density was recorded when the residual straw was around 3 t/ha. These effects may operate through the reduction of seed softening by the straw insulating the burr against fluctuating temperatures and direct effects of the straw on emergence.
- The effect of soil amelioration with gypsum can also increase medic plant density (Table 6). Gypsum is frequently applied to hard setting soils to enable minimum tillage cropping systems to be adopted. Medic density following a cereal crop was almost doubled where gypsum was applied in the pasture the year before cropping. As plant density governs early winter production the use of gypsum may give useful increases in medic production and autumn carrying capacity.

Table 6. Circle Valley medic regeneration following a cereal crop where gypsum had been applied before sowing the pasture

Seeding rate in 1984	Regeneration after a crop (plants/m^2) No gypsum	5 t/ha gypsum
2	248	498
4	262	466
8	412	908
16	412	680
32	568	1,000
Mean	380	710

Other factors which may determine the persistence of annual legumes are seed dormancy, rate of imbibition and rate of radical growth. Few researchers have studied the influence of these factors on the persistence of annual pasture species. Observational evidence suggests that medics on the soil surface require a higher rainfall event to cause germination than those which are buried. Crawford (pers com) has suggested that the spines on M. truncatula act as wicks drawing water from the soil surface into the burr. The effect of pod type on germination is also poorly understood. Do medics with low seed to pod ratios (high degree of pod material) hold water longer than thin podded medics which may dry out quicker following the rainfall event? Observational evidence also suggests that Serena burr medic has a slow rate of imbibition compared to M. truncatula cv. Cyprus.

The above areas of seed physiology require further study if we are to fully understand the effects of crop rotations on legume pasture species persistence.

Insect pest control

Pasture aphids, red legged earth mite, lucerne flea and sitona weevil have been implicated in the decline of legume pasture stands in southern Australia (Carter et al. 1982).

Bluegreen aphid can cause dry matter and seed yield losses in the order of 50-70%, while up to 80% seed loss in subterranean clover has been attributed to red-legged earth mite (Michael 1989). The control of red-legged earth mine results in increased stock carrying capacity of between 0.6-1.6 sheep per hectare. The control of red-legged earth mite in spring can significantly increase the seed yield of pasture legumes (Table 7).

Sitona weevil has been a major pest of medics in eastern Australia and has only recently been observed in medics in Western Australia. Allen (pers com) has found that sitona weevil has little effect on nitrogen fixation of an established barrel medic stand. The effect in Western Australia may be more severe, particularly in newly sown stands.

The major objective of both the medic and subterranean clover breeding programmes is to find clovers and medics resistant to red-legged earth mite and lucerne flea. The impact of such lines on pasture production across Australia would be large.

Table 7. The effect of controlling red-legged earth mite in spring on the seed yield of annual pasture species

Species	Cultivar	Seed yield (kg/ha) Spray	No spray	% decrease
M. murex	Zodiac	203	3	98
M. polymorpha	Circle Valley	652	573	12
M. truncatula	Paraggio	457	406	11
O. compressus	Tauro	214	160	25
T. subterraneum	Seaton Park	155	48	69
T. yanninicum	Trikkala	210	154	27
T. cherleri	Beenong	437	480	+10
T. balansae	Paradana	156	117	25

Screening subterranean clover genotypes for red-legged earth mite resistance has isolated some lines with useful resistance. Within the National Medic Improvement Programme there appears to be lines of M. aculeata, M. polymorpha, M. rugosa and M. scutellata with resistance to red-legged earth mite. Some lines of M. polymorpha and M. rugosa have useful resistance to lucerne flea, however, little useful resistance to spotted alfalfa aphid has been found in M. polymorpha (Lake 1988). The chances of using interspecific crossing to transfer resistance is also limited due to M. polymorpha having a 2n 14 chromosome number.

Weed control

Weed control in annual legume pasture has traditionally been achieved through strategic grazing management, however, in recent years the development of grass selective herbicides now allows the control of annual grasses in legume pasture. This has the benefit of providing a disease break phase for take-all, cereal cyst nematode and Desiantha weevil.

Thorn (unpublished) compared the effect of ryegrass density and defoliation on burr medic (Circle Valley) seed yield (Table 8).

Table 8. Effect of ryegrass density and defoliation on the seed yield of Circle Valley burr medic

Defoliation ryegrass density:	Circle Valley seed yield (kg/ha) 0	500	1,000	5,000	10,000
D_0	939	651	555	330	291
D_1	657	467	451	362	309
D_3	347	315	237	331	212

D_0 - undefoliated.
D_1 - defoliated from 42 days after sowing until 90 days at 2.5 cm.
D_3 - defoliated from 42 days after sowing until 120 days at 2.5 cm.

In undefoliated swards (D_0) there was a large competitive effect of annual ryegrass on Circle Valley seed yield, however, defoliation reduced the competitiveness of ryegrass. Seed producers can gain large medic seed yield increases by the use of selective grass controlling herbicides.

The control of broadleaf weeds in legume pastures is more difficult, with the major problem weeds being doublegee (Emex australis). There appears to be wide variability in the effect of various broadleaf herbicides both within a species and across species of annual pasture legumes (Bowran pers com).

In general terms the sensitivity of pasture legume species to broadleaf herbicides in order of decreasing tolerance were: M. truncatula > T. subterraneum > M. polymorpha > 0. compressus > to Medicamine[?], Tribunil[?], and Diuron/24DB and high rates of SN10664. Subterranean clover was most sensitive to Trifolamine[?] and Diuron/24DB, while serradella was most sensitive to Medicamine[?], Trifolamine[?] and Tribuni10.

Serena (burr medic) and Zodiac (murex medic) were the two cultivars most sensitive to the range of broadleaf herbicides. Seaton Park subterranean clover was more sensitive to the broadleaf herbicides than either Dalkeith or Daliak.

Kenny et al. (1987) found that persian clover tolerated MCPA (Na salt and amine) better than 2,4DB (ester, amine, Na salt), while 2,4D amine and Bromoxynil were more damaging.

There may be scope for the selection of lines of annual legume species with tolerance to broadleaf herbicides. Future work on broadleaf herbicides with legume pasture safety is necessary.

Fertilizer management

Quinlivan et al. (1983) showed that seed yields of Daliak subterranean clover responded to applied phosphate on newly cleared sandplain soils.

Bolland (1985) showed that on newly cleared soils, the seed yield response of subterranean clover and serradella was linear with the amount of phosphorus applied, with seed yield increasing by 7-24 kg/ha for each kg/ha of phosphorus applied.

A curvilinear response in medics seed yield was measured on alkaline soils with little response to applied phosphorus above 100 kg/ha. In both cases the size of the response depended on species, cultivar and location.

In the 1970s and early 1980s many farmers stopped topdressing pastures and increased the use of diammonium phosphate in the cereal crop. Reeves (1987) raised the question of the long term effects of such actions on pasture legume persistence.

Bolland (1985) found that on sandplain soils at Esperance, Western Australia that neither serradella nor subterranean clover responded to cobalt application. The winter herbage yields of serradella were increased by 3-8 fold by the application of fertilizer nitrogen. These effects did not follow through to spring production or seed yield. He concluded that low winter temperatures limited the rate of symbiotic nitrogen fixation in serradella. This was temporarily overcome by the application of nitrogen fertilizer.

There is a need to continually determine the nutrient requirements of new pasture species. Does the deeper rooted annual medic M. murex require less applied phosphorus, potassium and sulphur because it can explore more soil? What is the sulphur requirement of burr medic?

The use of lime to ameliorate soil acidity may enable the use of mixtures of subterranean clover and medics on acid soils. Little research has been conducted to determine the cost/benefit of the use of lime and species mixtures. This situation should be corrected in the coming years.

High boron levels in the soil have recently been found to have toxic effects on some plants. As these high boron soils are wide spread in the South Australian medic zone, the National Medic Improvement Programme has screened a number of Medicago species for tolerance to boron. Further study of boron toxicity in annual medics is required (Lake 1988).

Pasture legume species mixtures

Pasture legumes differ in their ability to persist in mixtures. Subterranean clover dominated mixtures when continuously grazed (Taylor and Rossiter 1974); but this work did not have a cropping phase and the results only apply to permanent pastures. The success of a pasture species in mixture will depend on initial seed set, degree of hard seed, rotation, grazing pressure, herbicide tolerance and the use of lime.

In 1988 a grazing trial on subterranean clover (Junee/Seaton Park), Zodiac murex medic and a 50:50 mix was conducted at Kojonup. Seed yield data suggest that M. murex is not very competitive in a mixture with subterranean clover (Fortune 1989) (Table 9).

Table 9. Seed yield of subterranean clover and M. murex cv. Zodiac in monoculture and mixture

	Seed yield (kg/ha)		
	Subterranean clover	Murex medic	Total
Seaton park/Junee	400	-	400
Zodiac	-	341	341
Mixture	217	61	278

Conclusions

Many factors affect the management of annual legume pastures. Insect pests, pasture species, disease, rotation, fertilizer management, weed control and grazing management are all important factors in the management of annual legume pasture. Understanding of how the various factors interact with one another is the key to successful pasture production and persistence.

There is a need for further research into the management of species mixtures; the role of soil ameliorants (lime, gypsum) on pasture production; the physiological response of pasture plants to grazing; the effect of insects on production; the comparative production, dry matter and growth rate differences betweeen species; the effect of summer grazing on seed reserves; the effect of pod type on seed digestion; the development of more 'niche' specific pasture species; seed physiology and germination characteristics of new pasture species; and the tolerance of pasture species to broadleaf herbicides.

The challenge is with advisers and researchers alike to provide producers with more knowledge in the area of pasture management if we are to make further gains in livestock carrying capacity and farm profit.

References

1. Andrews, P., Collins, W.J. and Stern, W.R. (1977). Withholding water during flowering on seed production of Trifolium subterraneum L. Australian Journal Agricultural Research. 28, 301-307.

2. Bolland, M.D.A. (1986). Effects of phosphorus on seed yields of subterranean clover, serradella and annual medics. Australian Journal of Experimental Agriculture, 25. 595-602.

3. Bolland, M.D.A. (1985). Assessment of methods of re-seeding subterranean clover near Esperance, Western Australia. Australian Journal of Experimental Agriculture, 25. 886-92.

4. Bolland, M.D.A. (1985). Effect of nitrogen and cobalt application on herbage and seed yields of serradella and subterranean clover. Australian Journal of Experimental Agriculture, 25, 588-94.

5. Carter, E.D. (1978). A review of the existing and potential role of legumes in farming systems of the near east and north African region. A report to the International Centre for Agricultural Research in Dry Areas (ICARDA).

6. Carter, E.D. (1982). The need for change in making the best use of medics in the cereal-livestock farming systems of South Australia. Proceedings 2nd Australian Agronomy Conference. Wagga Wagga, New South Wales, pp. 32.

7. Carter, E.D. and Challis, S. (1987). Effects of depth of sowing medic seeds on emergence of seedlings. Proceedings of the 4th Australian Agronomy Conference, La Trobe University, Melbourne. pp. 192.

8. Carter, E.D., Wolfe, E.C. and Francis, C.M. (1982). Problems of maintaining pastures in cereal-livestock areas of southern Australia. Proceedings 2nd Australian Agronomy Conference. Wagga Wagga, New South Wales pp. 68-82.

9. Collins, W.J. (1978). The effect of defoliation on inflorescence production, seed yield, and hard-seededness in swards of subterranean clover. Australian Journal of Agricultural Research. 29, 789-801.

10. Crawford, E.J. and Nankivell, B.G. (1989). Effect of rotation and cultivation systems on establishment and persistence of annual medics. Australian Journal of Experimental Agriculture; 29, 183-8.

11. Dunlop, A.C., Bowden, J.W. and Allen, G.M. (1984). The effect of stocking pressure on dry matter production in Mediterranean annual pastures. Animal Production in Australia. Proceeding of the Australian Society of Animal Production. 15, 333.

12. Ewing, M.A. (1989). Pasture establishment technique. Proceeding of Seminar 'Pastures for profit'. Geraldton, March 1989. Western Australian Department of Agriculture Miscellaneous Publication No. 6/89.

13. Fortune, J.M., Stern, W.R. and Thorn, C.W. (1989). Seed yield from Medicago murex grown alone and with sub.clover. Proceedings of the 5th Australian Agronomy Conference. Perth.

14. Gillespie, D.G. (1989). Experimental Summaries - Plant Industry Division, Western Australian Department of Agriculture.

15. Gillespie, D.J. (1988). Evaluation and development of murex medic in Western Australia. Proceeding of National Medic Improvement Programme Workshop. April 1988. Australian Wheat Industry. In Press.

16. Gillespie, D.J. (1988). Murex medic - a new pasture species. Western Australian Journal of Agriculture, 29, 132-138.

17. Heida, R. and Jones, R.M. (1988). Seed reserves of barrel medic (Medicago truncatula) and snail medic (M. scutellata) in the top soil of pastures on a Brigalow soil in southern Queensland. Tropical Grasslands. 22, 16-21.

18. Kenny, P.T., Hill, R.D. and Reed, K.F.M. (1987). Tolerance of persian clover seedlings to broadleaf herbicides. Proceedings of the 4th Australian Agronomy Conference, La Trobe University, Melbourne. pp. 186.

19. Lake, A.W.H. (1988). The National Medic Breeding Programme. Proceeding of National Medic Workshop. April 1988. Australian Wheat Industry. In press.

20. Michael, P. (1989). Insect Control. Proceeding of Seminar 'Pastures for profit'. Geraldton. March 1989, Western Australian Department of Agriculture. ***Misc.*** Publication No. 6/89.

21. Nicholas, D.A. (1989). Cropping and pasture legume production. Proceedings of seminar "Producing pastures for profit" March 1989. Geraldton. Western Australian Department of Agriculture Misc. Publication No. 6/89.

22. Poole, M.L. and Gartrell, *J.* (1970). Undersowing wheat with annual legumes: effects on wheat yields and legume seed yields in the south-east wheatbelt of Western Australia. Australian Journal Experimental Agriculture and Animal Husbandry 10, 84-88.

23. Quigley, P.E., Carter, E.D. and Knowles, R.C. (1987). Medic seed distribution in soil profiles. Proceedings of the 4th Australian Agronomy Conference, La Trobe University, Melbourne, pp. 193.

24. Quinlivan, B.J., Devitt, A.C. and Francis, C.M. (1973). Seeding rate, time of sowing and fertilizers for subterranean clover seed production. Australian Journal of Experimental Agriculture and Animal Husbandry. 13, 681-4.

25. Reeves, T.G. (1987). Pastures in Cropping Systems. Temperate Pasture, their production, use and management. Ed. J.L. Wheeler, C.J. Pearson, G.E. Robards. Aust. Wool. Corp. Technical Publication.

26. Revell, C.K. and Ewing, M.A. (1988). Santiago extends the range of burr medics. Western Australian Journal of Agriculture 29, 139-142.

27. Revell, C.K. and Thorn, C.W. (1984). Experimental summaries - Plant Industry Division. Western Australian Department of Agriculture.

28. Rossiter, R.C. (1966). The success or failure of strains of Trifolium subterraneaum L. in a Mediterranean environment. Australian Journal of Agricultural Research. 17, 425-46.

29. Rossiter, R.C. (1977). What determines the success of subterranean clover in south-western Australia. Proceedings Ecological Society of Australia. 10, 76-88.

30. Taylor, G.B. (1985). Effect of tillage practices on the fate of hard seeds of subterranean clover in a ley farming system. Australian Journal of Experimental Agriculture. 25. 568-73.

31. Taylor, G.B. and Ewing, M.A. (1988). Effect of depth of burial on the longevity of hardseeds of subterranean clover and annual medics. Australian Journal Experimental Agriculture. 28, 77-81.

32. Taylor, G.B. and Rossiter, R.C. (1974). Persistence of several annual legumes in mixtures under continuous grazing in the south-west of Western Australia. Australian Journal of Experimental Agriculture and Animal Husbandry. 14, 632-639.

33. Taylor, G.B. and Rossiter, R.C. (1969). Seed production from three annual species of Trifolium on sandy soils in the wheatbelt of Western Australia. Australian Journal Experimental Agriculture and Animal Husdandry. 9, 92-98.

34. Thorn, C.W. (1989). Grazing Management and Pasture Utilization Proceedings of Seminar "Producing pastures for profit" March 1989. Geraldton. Western Australian Department of Agriculture Misc. publication No. 6/89.

35. Thorn, C.W., Revell, C.K. and Ewing, M.A. (1988). Production from and management of burr medic pastures. Western Australian Journal of Agriculture, 29, 48-53.