4-1995

Productive pastures pay - a manual on pasture establishment and management for the above 700 mm rainfall zone

P T. Arkell

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Productive Pastures Pay

A manual on pasture establishment and management for the above 700 mm rainfall zone

Compiled by Peter Arkell
Productive Pastures Pay

A manual on pasture establishment and management for the above 700 mm rainfall zone

Compiled by
Peter Arkell
Bunbury District Office
Department of Agriculture

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Acknowledgement

Many people have contributed to ‘Productive Pastures Pay’. Without all their help the manual could not have been produced. So the South-West Pasture Group, Tony Albertsen, Bill Smart, Bill Russell, Kerry Hawley and Peter Arkell, who planned and directed the pasture manual’s production, thank most sincerely all those people and organisations who helped with the manual.

The concept of this manual and some of the material are derived from the ‘Establishment field guide’, produced by NSW Agriculture and agribusiness as part of the Prime Pasture Program.

Our special thanks to NSW Department of Agriculture and National Landcare Program Project Leader, Michael Keys of Queanbeyan, for permission to use their material.

Farmers, Department of Agriculture colleagues and agribusiness personnel provided critical comment and feedback. It was much appreciated.

Bunbury clerical staff Trina Bigwood and Jodi Saunders typed the first and second drafts. Information and Media Services editorial and design staff turned the manual into a publishable product.

Our sponsors, CSBP and Farmers, Pacific Seeds, Valley Seeds, Bunbury Machinery, Hardi Spraying Equipment and Alcoa Land Care provided essential finance. Special thanks to our sponsors.
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Foreword

The total value of production from the dairy, beef and sheep enterprises in the south-west high rainfall region (above 700 mm) of Western Australia was $250 million in 1992/93. Of this 44 per cent came from milk production. Sustained profitability of these industries depends upon high levels of pasture productivity and use.

To maintain its relevance to the future of these agricultural industries, the Department of Agriculture has focused its diverse range of activities into programs dealing with various industries or production systems. The sustainability of agriculture in the future will depend on farmers selecting the enterprise mix and production systems most appropriate to their land and maintaining or enhancing productive capacity through up-to-date management. For pasture-based industries, this translates into improvement of current pasture species, the use of a wider diversity of species in farming systems, sound pasture renovation and fertiliser practices and better use of pastures through more efficient grazing management.

For improvement to occur, farming decisions must be based on relevant, up-to-date information that is scientifically sound and easily applied. This pasture manual brings such information to you in one package. I commend the use of this manual to you. It is one step towards a profitable future in farming. I’m sure you will come back to it again and again.

I would appreciate receiving comment on this manual, through your Development Officer, so that future editions can be improved.

Geoff de Chanéct
Regional Manager, South-West Region
Productive pastures pay

Farm profit in a grazing enterprise depends a great deal on pasture productivity and the efficiency of pasture use. These two factors in combination influence stocking rate, production per animal and production per hectare and hence farm profit.

The Beef Improvement Association (WA Branch) 1993/94 Beef Farm Survey showed that high stocking rates and good pasture management contribute significantly to beef farm profits. Gross margins ranged from $7 to $541/ha with an average of $216/ha. Stocking rates ranged from 0.58 to 1.54 breeding units/ha (average 1.06). Gross margins/ha were higher on farms with higher stocking rates. On dairy farms, high stocking rates also contribute to dairy farm profitability.

This manual on pasture establishment and management is designed to help farmers grow productive pastures. It deals with annual and perennial pastures on dryland and irrigated farms in the above 700 mm rainfall zone and may be used by individual farmers or discussion groups. Input from discussion groups will improve future editions of the manual.

Farmers frequently need to reseed their pastures. Pastures deteriorate and new, more productive species and cultivars come on to the market. Also improved techniques are developed to tackle land management problems like salinity, waterlogging and acidity. All these situations lead to a reseeding operation.

A successful reseeding operation is highly profitable. Failure is expensive. When a reseeding operation fails the big cost is the failure to produce a more productive pasture.

The reseeding operation itself may be faulty, being poorly planned or poorly executed. Often a paddock is reseeded because the pasture has deteriorated but the cause of the pasture deterioration has not been identified. Reseeding, without tackling the underlying problem often leads to failure, however competent the reseeding operation.

Alternatively a deteriorated pasture can often be restored to full production or a productive ryegrass encouraged to persist by changing paddock management.

So assessing the pasture, its botanical composition, health and productivity and the soil it is growing in are important initial steps in a reseeding operation. This assessment also helps you decide whether to reseed the paddock or change the paddock’s management.

The Waterloo Farmers' Forum discussing kikuyu management.
Economics of pasture improvement

Pastures are the backbone of any grazing enterprise. Improving pasture productivity often increases livestock profitability.

It seldom costs less than $2500 per hectare to buy grazing land in the south-west, and the land typically carries one breeding cow per hectare. Leaving aside any appreciation in land value, this is equivalent to spending $250/ha on your own land to gain a permanent 10 per cent increase in carrying capacity.

Increasing livestock numbers on land you already own makes better use of capital improvements (fences, yards, watering points, etc.) and is easier to manage.

Even if pasture improvement work is needed every five years, the extra income is often double the extra costs.

On most farms, several alternative pasture improvement investments compete for your time and money. The best option is the one that gives you the greatest return in proportion to your most limiting resource – cash, land or labour.

If the most profitable option is not obvious, weigh up the alternatives with a simple budget.

The cash flow development budget

A cash flow budget compares costs with extra income, over several years.

Paddock treatment is the most obvious cost, but the initial loss of feed when a paddock is sprayed out or cultivated, or while new pastures are getting established, is also important.

In the following examples, expected changes in productivity are expressed as changes in stocking rate. In Example 1 – a dryland pasture improvement project – the livestock unit (LSU) is a beef cow and calf. In Example 2 – irrigated pasture renovation – the livestock unit (LSU) is a milking cow.

The method is the message

The purpose of these examples is to show how to assess the profitability of a pasture improvement project and illustrate two particular examples. The spreadsheet model used to produce the tables and the graph is available to farmers and discussion groups who have access to a computer.

To help farmers prepare their own budgets a ‘Do-it-yourself pasture improvement budget form’ appears at the end of the article.

It is convenient to account for expected changes in productivity as changes in stocking rate, even though this oversimplifies the effects on quality and seasonality of production.

Example 1. Pasture improvement budget at $200/LSU for dryland pasture improvement, 20 ha

In Example 1, an imaginary paddock of rundown annual pasture on a beef farm is resown to improved ryegrass and subterranean clover cultivars, with lime, extra nitrogen and potash. The beef farm has a gross margin of $200 per livestock unit after allowing interest on the value of the livestock.

The project involves spraying out existing pasture and weeds, spreading 2.5 t/ha of lime, drilling in 10 kg/ha of Concord ryegrass plus 7 kg/ha of Goulburn and 7 kg/ha of Trikkala and topdressing with 60 kg/ha of urea and 50 kg/ha of potash.

A single application of insecticide is allowed for. From Year 2 onwards an extra 25 kg/ha potash is applied. Liming is not needed again for another 10 years.

Reseeding the pasture increases carrying capacity from 0.8 LSU/ha to 1.2 LSU/ha.

The feed lost during reseeding is accounted for in the budget by reducing the carrying capacity in the first year from 0.8 to 0.6 LSU/ha, equivalent to a drop in gross margin of $40/ha.

Figure 1 illustrates Example 1 (gross margin $200/LSU) and compares it with a similar project on a beef farm with a gross margin of $100/LSU and an irrigated pasture project with dairy cows at $400/LSU.

At $200/LSU the project breaks even in the fourth year and over the seven years budgeted is very profitable (a 37 per cent return on investment). It would not be profitable if the gross margin per livestock unit were only $100.

Example 2. Renovation of a 10 ha kikuyu dominant irrigation paddock

Example 2 is a three stage project on a kikuyu dominant irrigated pasture. It begins in the first autumn with slashing to remove excess kikuyu, spraying with glyphosate at 2.5 L/ha and burning.
Drainage is improved by spinner cuts down the paddock and cleaning out the tail drain. The paddock is then sown with 20 kg/ha of Concord ryegrass. Extra urea is spun out at 80 kg/ha.

In the following spring the paddock is cultivated and sown with 15 kg/ha of millet.

In the second autumn the paddock is again sprayed with glyphosate at 2.5 L/ha and sown with 7 kg/ha Embassy, 8 kg/ha Ellett and 8 kg/ha Concord ryegrass, plus 3 kg/ha Haifa and Kopu perennial white clover. A further 80 kg/ha of urea is applied.

Annual drainage maintenance is an on-going cost of the project to ensure the benefits are realised.

Pasture renovation raises carrying capacity of this pasture from 1.6 L.SU/ha to 3 L.SU/ha for three years, so the gross margin increases from $640/ha to $1200/ha. After that the kikuyu takes over again, and productivity returns to the original level in Year 7. Good management – irrigating at 70 mm evaporation, drainage, ripping and keeping the kikuyu under control – will maximise and prolong the benefit from renovation.

A gross margin of $400/LSU would be appropriate for dairy cattle because extra production is sold as manufacturing milk and the $400/LSU includes the cost of extra livestock capital.

This project breaks even in the second year and is very profitable. Over the seven years budgeted it has an internal rate of return of 130 per cent under the assumptions used.

Some benefits could be expressed in terms of the value of extra hay produced from the improved pasture, net of hay making expenses.
EXAMPLE 1. PASTURE IMPROVEMENT BUDGET for a 20 ha DRYLAND block

Introducing new ryegrasses to annual pasture

ASSUMPTIONS
Area of land (ha) 20
Cost of improvement/ha $231
Cost of extra maintenance/ha $8
Gross margin/livestock unit $200
Interest on debt 10%
Interest on credit 10%

COSTS in Year 1:
- Spraying $15.00/ha
- Drilling $25.00/ha
- Concord @ 10 kg/ha $35.00/ha
- Goulburn/Trikkala @ 7+7 kg/ha $42.00/ha
- Spreading $5.00/ha
- Extra urea @ 60 kg/ha $24.00/ha
- Lime @ 2.5 t/ha $65.00/ha
- Extra potash @ 50 kg/ha $15.00/ha
- Insect control $5.00/ha
TOTAL $231.00/ha

Other costs:
- Every year extra potash @ 25 kg/ha $8.00/ha
- Lime @ 1 t/ha every 10 years $40.00/ha

CALCULATIONS

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>0.6</td>
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<td>22</td>
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PROJECT COSTS
- Pasture improvement ($4,620) $0 $0 $0 $0 $0 $0 $0 $0
- Pasture maintenance $0 $0 ($160) ($160) ($160) ($160) ($160) ($160)

PROJECT BENEFITS
- Extra profit $0 $2,400 $2,400 $2,400 $2,400 $2,000 $2,000 $1,600

FINANCIAL
- Interest ($462) ($508) ($319) ($127) $84 $317 $533 $770

CASH BALANCE
- ($-5,082) ($-3,190) ($-1,269) $844 $3,168 $5,325 $7,698 $9,907
(advantage over no change)
EXAMPLE 2. RENOVATION of a 10 ha KIKUYU DOMINANT IRRIGATION Paddock

ASSUMPTIONS
Area of land (ha) 10
Cost of improvement (Year 1)/ha $274
Cost of improvement (Year 2)/ha $221
Cost of extra maintenance/ha $15
Gross margin/livestock unit $400
Interest on debt 10%
Interest on credit 10%

COSTS:

Autumn Year 1
Slash to remove excess kikuyu $15.00/ha
Spray glyphosate CT @ 2.5 L/ha $27.00/ha
Burn $5.00/ha
Improve drainage - spinner cuts $5.00/ha
- clean out tail drains $30.00/ha
Sow ryegrass and clover $25.00/ha
Concord seed @ 20 kg/ha $80.00/ha
Spin out urea $5.00/ha
Extra urea @ 80 kg/ha $32.00/ha
Sub-total $224.00/ha

Spring Year 1
Millet @ 15 kg/ha $20.00/ha
Cultivation and drilling $30.00/ha
TOTAL YEAR 1 COST $274.00/ha

Autumn Year 2
Spray glyphosate @ 2.5 L/ha $27.00/ha
Concord seed @ 8 kg/ha $30.00/ha
Ellet and Embassy @ 8+7 kg/ha $53.00/ha
Haifa @ 3 kg/ha $16.50/ha
Spin out urea $5.00/ha
Extra urea @ 80 kg/ha $32.00/ha
TOTAL YEAR 2 COST $220.50/ha

CALCULATIONS

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<td>25</td>
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PROJECT COSTS
Pasture improvement ($2,740) ($2,205) $0 $0 $0 $0 $0 $0
Pasture maintenance $0 $0 ($150) ($150) ($150) ($150) $0 $0

PROJECT BENEFITS
Extra profit $0 $5,600 $5,600 $5,600 $3,600 $1,600 $0 $0

FINANCIAL
Interest ($274) ($301) 85 554 1,154 1,615 $0 $0
CASH BALANCE $-3,014 $80 $5,538 $11,541 $16,145 $19,210 $19,210 $19,210 (advantage over no change)
# DO-IT-YOURSELF PASTURE IMPROVEMENT BUDGET

**ASSUMPTIONS**

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<tr>
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<td>Area of land (ha)</td>
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<tr>
<td>Cost of improvement/ha</td>
<td>$........... /ha</td>
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<td>Cost of extra maintenance/ha</td>
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<tr>
<td>Gross margin per livestock unit</td>
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<tr>
<td>Interest on debt (%)</td>
<td>$........... /ha</td>
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<tr>
<td>Interest on credit (%)</td>
<td>$........... /ha</td>
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**COSTS in Year:**

- **Spraying** $........... /ha
- **Drilling** $........... /ha
- **Seed @ ........ kg/ha** $........... /ha
- **Spreading** $........... /ha
- **Fertiliser @....... kg/ha** $........... /ha
- **Lime @ ........ t/ha** $........... /ha
- **Insect control** $........... /ha
- **$........... /ha Extra maintenance costs** $........... /ha

**CALCULATIONS**

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<th>Year</th>
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**PROJECT BENEFITS**

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**FINANCIAL**

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<tr>
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**CASH BALANCE**

(advantage over no change)
Boost your winter pasture production with quality products from PACIFIC SEEDS

Plan ahead and maintain high levels of winter milk production. These varieties will provide high volumes of good quality feed.

**EMBASSY**

A very erect perennial ryegrass, ideal for intensive production pasture mixes.
- Upright stance ensures good clover establishment
- Excellent persistence ensures long term pasture production
- Good disease resistance

**ROBERTA**

Highly productive annual ryegrass. Main growth period is autumn-winter-spring.
- Very high winter/spring herbage yields
- High seedling vigour
- Can persist into a second season in more temperate southern areas

**Goulburn**

High producing sub clover. Mid to late season maturity with good disease resistance.
- High hard seed levels ensure good regeneration
- Prostrate growth and high yield means excellent persistence
- High herbage producer

**DEMAND**

A high yielding, persistent type suitable for pasture mixes in a range of conditions.
- Medium to medium-large leaf size
- Excellent early establishment
- A very cost effective alternative

**Caliph**

Self generating annual pasture legume. Resistant to spotted alfalfa and blue green aphid.
- Early vigour, early maturity, high hard seed levels
- Excellent producer of herbage and seed in preferred environment
- Can provide 70 to 80 kg/ha of residual N for following crop

For more information contact:
Dean Teague, SEED & GRAIN BROKERS (WA)
Ph: (09) 445 3677  Fax: (09) 445 3912
Bill Smith, PACIFIC SEEDS
Ph: (076) 902 666  Fax: (076) 301 063

For a FREE copy of "UPGRADE YOUR PASTURES", contact
Pacific Seeds PO Box 337, Toowoomba, Qld 4350 - Phone: (076) 902 666 or Fax: (076) 301 063
Planning the renovation program

In a renovation program, you should be looking for the best return for dollars spent. Good planning is essential

On a whole farm basis the biggest question is how does your production per hectare and profit per hectare compare with your neighbours? How big are paddock to paddock variations? Why do they vary? Do you need a program of pasture renovation for the whole farm?

Looking at the individual paddock ask yourself: Has the paddock deteriorated? Does it need reseeding or will a change in management restore productivity? If it has deteriorated, why? Has your grazing management caused the problem? Is the soil low in nutrients or too acid or too salty? Have insects been a problem? Which ones? Have weeds invaded the pasture? Which ones? If you don’t sort this out before you start, you run the real risk of spending money for little long-term return.

For some weeds, control should start in the spring before you plan to renovate. For soil fertility problems, you need to soil test over summer. If you leave either of these to the last minute, you put yourself under unnecessary pressure.

If you are faced with big areas of run down pasture, where do you start? Quickest returns usually come from improving poor pastures on your best soils. The best soils usually have the fewest inherent problems and should respond rapidly. Leave your really poor soils till last or plant trees on them.

**Before you start – farm plan**

Pasture improvement is an expensive process and should be carried out as part of an overall farm plan. You need to think about what you are doing and how it will fit into your farming program. Do you expect to change your farm enterprises in the near future? If you do, will it mean changes in the layout of your fences? Is it possible to alter fencing to take better account of the variation in land forms and soil types on the farm, or to alternatively improve pasture use?

**Trees on farms**

What about tree planting – will you just plant along existing fences or will the benefits from shade/shelter/water use justify a new layout? These are some of the questions you should consider before you start on your pastures.

**Managing different soils**

There are benefits in fencing according to major soil types, especially where there are major differences in potential productivity between them. You will be better able to tailor your fertiliser program to the potential of the soil and it will make selecting suitable pasture species easier. Soils with very low agricultural potential can be planted to a tree crop, allowing you to concentrate on the soils with more potential.

**Vegetation**

Remnant vegetation on private land is a valuable resource which is under threat from many quarters. Once it is gone, it is almost impossible to get it back. Plan your farm so that the larger blocks of remnant vegetation can be fenced off and incorporated into new plantings of shade/shelter belts. Talk to your neighbours about a coordinated tree planting program so that you create a network of tree/shrub lines which link up remnants of native vegetation.

**Drainage**

Many of our soils are waterlogged or salt affected and need to be drained to realise their potential. Where a drainage network already exists, it will be used but the downstream effects of drainage are more important now than they used to be. Farming systems which use more of the water which falls on the land are the best methods of reducing the amount of water reaching the drains.

**Streamlining**

Vegetated strips along drains stabilise the drain bank, use water and help to strip out nutrients. They form part of the shelter system on the farm and serve as important wildlife refuges. (See Department of Agriculture Bulletin 4279, Streamlining’).

**Erosion**

Erosion is generally not a problem on soils under pasture unless overgrazed, but the renovation process can create conditions where wind or water erosion does occur. Some cultivated sandy surfaced soils blow badly with a strong easterly wind behind them and sloping areas wash if heavy opening rains fall on bare soil. You need to be aware of these potential problems when planning your renovation program.

If you are farming for the long-term, some time spent now working out how you want the farm to look in the future will be time well spent.
Assessing the pasture

Checking pastures is as important as checking stock. A monthly check works well but early in the season a weekly check may be needed, especially in a late break when pasture growth is slow. Check the grazing program and check for insect activity. If you plan a reseeding operation check the pasture the year before reseeding, during winter/early spring, to identify weed problems and the causes of pasture deterioration. Get off the bike, out of the utility and have a good look at the pasture. The 'hands and knees – attention to detail approach' when checking pasture pays off in better pasture management.

When checking for growth consider vigour, colour, density and health as well as yield. Make mental comparisons with last month, last year and other paddocks. Look for signs of undergrazing – tall, rank pastures with dead leaves rotting in the pasture bottom – and overgrazing – short, low density pastures with bare ground between plants and slow recovery from grazing. Patch grazing shows up as uneven grazing. It indicates poor use. Some areas are grazed hard, others are left ungrazed. Patch grazing occurs in set stocked paddocks, in continuously grazed pastures and in understocked, rotationally grazed pastures (see ‘Grazing systems and pasture management’ page 71).

**Botanical composition**

As a rough guide, good pastures have at least 30 per cent to 40 per cent clover or other recommended legume, 40 per cent to 70 per cent productive grasses and no more than 20 to 30 per cent weeds.

But animals also perform well on pastures with a high clover (50 to 100 per cent clover) content or a high productive grass content – if the grass is fertilised with nitrogen and on sandy soils, sulphur. Productive pastures are dense, leafy and well managed.

An unproductive pasture has a high proportion of weed grasses and broad-leaved weeds e.g. silver grass, brome grass, uncontrolled kikuyu or couch, corkscrew, capeweed, Guildford grass and dock. It lacks density, and bare ground may be exposed.

One method of assessing pasture composition is to determine the percentage of ground cover covered by each plant type.

- Stand in the paddock with your feet about half a metre apart. Visualise a square 0.5 m x 0.5 m in front of your toes.
- Estimate the proportion of this square that each plant type occupies.
- Take at least ten estimates in a line across the paddock.

**Hint:** Imagine the square divided into quarters. Mentally move plants of one type into one quarter - overflowing into the next quarter if necessary to gauge percentage. Repeat for other types in succession.

Botanical composition gives lots of clues on pasture health, pasture management and the causes of pasture deterioration. Ask yourself why is the pasture like it is? Why has it deteriorated? Solving these problems will help you plan the reseeding program and the after-seeding management.
### Recordings

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<th>Estimated percentage of ground cover</th>
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<th>9</th>
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<td>% clover/legumes</td>
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**A mountain of real winter feed**

- More feed in winter
- Higher returns
- Better quality

![PROGROW ANNUAL RYEGRASS 20% PROTEIN 25kg](image)
# Pasture problems and their indicators

A successful pasture renovation program depends on an accurate assessment of the pasture and the causes of its deterioration or its low productivity. These problems may have soil, pasture or management origins. The following table lists some of the problems and some ways they can be identified.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Indicators and causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Soil salinity</td>
<td>Unproductive low lying (poorly drained) land. Bare ground, barley grass, button weed, beard grass, little subterranean clover, white clover or capeweed present. Often grows ryegrass, balansa clover and lotus. Confirm by soil test and an EM 38 survey.</td>
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<tr>
<td>4. Overgrazing</td>
<td>Clover, flat weed, winter grass and chickweed present. Little ryegrass. Much bare ground, even in winter. Grazed hard to the ground.</td>
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<tr>
<td>5. Undergrazing</td>
<td>Low density, grassy pastures. Old decaying leaves near pasture base. Uneven grazing. Dead grass carried over into new season.</td>
</tr>
<tr>
<td>6. Waterlogging</td>
<td>Water-table 30 cm deep. Soggy wet ground, rushes, dock, pugging by stock.</td>
</tr>
<tr>
<td>7. Inundation</td>
<td>Even worse! Puddles everywhere.</td>
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<tr>
<td>8. Soil compaction</td>
<td><strong>Heavy loams and clays.</strong> Stock pugging, poor water infiltration, shallow rooting. Responds to ripping and draining. <strong>Sandy loams.</strong> Traffic hard pan at depth. Cereal hay crops respond to ripping 30 cm deep.</td>
</tr>
<tr>
<td>11. Capeweed dominance</td>
<td>High nitrogen status. Needs more productive, persistent grass. False break or severe redlegged earth mite attack has killed clover. Sandy soils, disturbed or overgrazed in summer. Lax grazing in winter.</td>
</tr>
<tr>
<td>12. Couch/kikuyu dominance</td>
<td>Undergrazing, high nitrogen use, salinity, waterlogging.</td>
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</table>
Key to identifying pasture problems

Ryegrass

Damaged or dying plants ——> Yes ——> Plant pulls out of ground easily or the plant top is lying on the ground ——> Yes

<table>
<thead>
<tr>
<th>No</th>
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<tbody>
<tr>
<td>Plant appears to be 'ring-barked' ——&gt; Yes ——&gt; Redlegged earth mites</td>
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</tbody>
</table>

Discoloured leaves ——> Yes ——> Discolouration localised on older leaves ——> No

<table>
<thead>
<tr>
<th>Yes</th>
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<tbody>
<tr>
<td>Whole leaf pale green, in extreme cases the older leaves turn yellow (chlorotic) and eventually die. This yellowing often starts at the tip of the leaf ——&gt; Yes ——&gt; Nitrogen deficiency</td>
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</tbody>
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<table>
<thead>
<tr>
<th>No</th>
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<tbody>
<tr>
<td>Leaves dark green, in extreme cases leaves have a red tinge. Tips of leaves are necrotic (dying appearance) ——&gt; Yes ——&gt; Phosphate deficiency</td>
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</table>

<table>
<thead>
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<th>No</th>
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<tbody>
<tr>
<td>Leaves show necrotic speckling and necrotic leaf tips and margins, giving a green arrow effect ——&gt; Yes ——&gt; Potassium deficiency</td>
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</table>

Discolouration localised on middle leaf ——> No

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<tr>
<th>Yes</th>
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<tbody>
<tr>
<td>Leaves have a grey green appearance Middle leaves necrotic in centre of leaf, and eventually leaf collapses from centre ——&gt; Yes ——&gt; Zinc deficiency</td>
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<table>
<thead>
<tr>
<th>No</th>
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<tbody>
<tr>
<td>Leaves are pale green. Middle leaves show longitudinal chlorotic striping. Necrotic tips and margins ——&gt; Yes ——&gt; Molybdenum deficiency</td>
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</table>

Discolouration localised in new leaves ——> No

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<th>Yes</th>
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<tbody>
<tr>
<td>Leaves are light green and the new leaves show marked chlorosis and necrotic tips. Eventually whole plant is chlorotic. ——&gt; Yes ——&gt; Sulphur deficiency</td>
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</tbody>
</table>

(continued over page)
No

Plant is light green. New leaves have light grey to translucent flecking and striping at base of the sheath. Necrotic areas at mid leaf and eventually collapse of the leaf at this point

No

Plant has green old leaves and pale young leaves

Yes

New leaves show interveinal chlorosis and in some cases whitening of the whole leaf, but no necrosis of the leaf

No

New leaves chlorotic folded and spindly, with yellow mottling and eventually necrotic tipping

Yes

Discolouration on terminal shoots

No

Yes

Plant is green, but the terminal shoot remains unopened. Necrosis appears in the centre of the shoot, with eventual collapse of the shoot centre

No

Plant is light green and wilting. New leaves are wither tipped, and terminal shoot dies, leading to necrosis and collapse of shoot

Yes

Discolouration to whole plant

Plant is red and when rubbed between the fingers the 'red' coat comes off onto your hand

Yes

Ryegrass thinning out in the sward (often replaced by weeds)

No

Symptoms as above

Yes

Ryegrass rust fungi (some varieties are more susceptible than others to this disease)

No

Clover dominant and ryegrass thinning out season by season

Yes

Grazing management

Grazing too severe in spring – seed set affected

No

Pasture rank and weeds dominate

Yes

Stocking rate too low
Key to identifying pasture problems

**Clover**

1. **Damaged or dying plants**
   - Yes → Holes in leaves
   - Yes → Pasture weevil
     - Cutworm
     - Lucerne flea
       - (frosted window effect green tissue partly removed)
   - No → Silvery white leaves
     - Yes → Redlegged earth mite
     - No → Stunted unthrifty plants. Poor growth
       - Swelling on roots (not nodules)
         - Yes → Eelworm
         - No → Dying plants
           - Yes → Root tissue
             - Yes → Root rot brown
             - No → Wilting, shrivelling leaves
               - Yes → insects on/under leaves
               - No → Stunted, red-purple seedlings
                 - Yellow cotyledons, no nodules, stubby roots → Yes → Acid soils

2. **Discoloured leaves**
   - Yes → Whole plant pale green/yellow
     - Leaf stalk reddened
       - Yes → Sulphur deficiency
       - No → New growth can be white
         - Yes → Iron deficiency
         - No → Pale green/yellow between leaf veins
           - Yes → New leaves, interveinal paling
             - Yes → Manganese deficiency
             - No → Pale, middle aged leaves may wilt. New shoots unopened growth poor
               - Yes → Copper deficiency
               - No → Young and middle leaves putty green. Short leaf stalks, stunted growth, rosetting of plants → Yes → Zinc deficiency
               - No → Young and middle leaves pale, mottled along margins, patches intensifying with time. Leaflets dark green at base and along mid rib. Convex rolling of leaflets → Yes → Magnesium deficiency
               - No

(continued over page)
Uniformly pale green, small, limp leaves. May be some reddening of leaf stalks and older leaves. White or greenish nodules when dissected → Yes → Molybdenum deficiency

No

Leaf spotting, paling/bronzing and scorching leaf margins → Yes → Potassium deficiency

Stunted/distorted plants → Yes → Leaves blue-green/purple, stunted. Leaf stalks red → Yes → Phosphorus deficiency

No


No

Veins clearing, yellowing between veins, mottling, leaf deformation. Plants dwarfed → Yes → Bean yellow mosaic virus (susceptible varieties – Karridale, Denmark, Leura, Meteor)

No

Leaves curled downwards, faintly mottled, plants dwarfed → Yes → Cucumber mosaic virus

No

Roddening of leaves, spread by aphids from white clover to subterranean clover → Yes → Subterranean clover red leaf virus

Clover thinning out, being replaced by grasses and/or weeds → Yes → Symptoms as above → Yes → Insect, nutritional or disease problems as above

No

Stunted, red-purple seedlings, yellow cotyledons. No nodules, stubby roots → Yes → Acid soil

No

Densely overgrown with annual ryegrass → Yes → Undergrazing

No

Heavy use of nitrogen → Yes → Undergrazing

(continued over page)
Pastures tall, rank, not short cropped in spring → Yes → Undergrazing

Pastures waterlogged in winter → Yes → Varieties not tolerant to waterlogging

Presence of button weed/barley → Yes → Land becoming saline grass in damp/waterlogged areas
Paddock records

Good paddock records help you monitor progress in many areas. Records of fertiliser use, soil test and tissue test results help you monitor paddock fertility. Hay and silage records and grazing records help you monitor productivity. Some record sheets are included in this manual. Use these or design your own.

Grazing record notes

- Date in – date cattle entered the paddock
- Animal type – describe animals, e.g. beef breeders, in calf heifers, milkers, etc.
- Quantity – number of animals
- Cow unit (CU)
- Date out – date the cattle were removed from the paddock.
- Cow days – multiply the number of days by the number of cow units.

The ‘cow unit’ system is used because animals vary in size and type, so recording the number of head in the paddock can be misleading. On a beef farm the cow unit equates to a cow and a calf. In liveweight terms the beef cow unit ranges from 550 kg before calving in autumn to a total of 750 kg for the cow and calf in spring. For younger stock estimate their weight and calculate the cow unit equivalent.

- A beef cow and calf = 1 cow unit.
- A lactating dairy cow = 1 cow unit.
- A yearling weighing 300 kg = 0.6 cow units.

It is a rough, simple guide.

Sheep farmers

Use dry sheep equivalents (DSE) instead of cow units

1 wether = 1 DSE
1 adult ewe = 1.5 DSE
1 ram = 1.3 DSE
1 weaner = 0.9 DSE

---

ALCOA AUSTRALIA

Since 1990 Alcoa has provided more than $6.5 million to the Western Australian landcare movement. Projects assisted include:
- Six Avon Catchment Groups
- Lake Toolibin Recovery
- Tammin Alcoa Landcare Education Centre
- Avon Ascent
- 44 Farmer and Community projects in the Alcoa Region

Alcoa, working in close conjunction with the Western Australian Department of Agriculture, is a major supporter of farmer and community landcare groups in WA.

Alcoa has also sponsored a number of Statewide projects managed by Greening Western Australia:
- Plants for Conservation 1.3 million trees
- Regional Plant I.D. kits
- Direct seeding demonstrations
- Seed orchards
- Grow us a home
- Ribbons of Green

---

... Supporting landcare

... Helping community environmental projects
<table>
<thead>
<tr>
<th>Date in</th>
<th>Type of animal</th>
<th>Number of animals</th>
<th>Cow units or DSEs</th>
<th>Date out</th>
<th>Cow or DSE days</th>
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Paddock Record - 1
Grazing Record

Paddock ........................................ Area (ha) ........................................
# Paddock Record - 2

Paddock ................................................. Soil type ......................................................

Area (ha) .....................................................

Soil test results

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<thead>
<tr>
<th>Year</th>
<th>Phosphorus (ppm)</th>
<th>Potassium (ppm)</th>
<th>Reactive iron (ppm)/PRI*</th>
<th>Salt (mS/m)</th>
<th>pH in calcium chloride</th>
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* Phosphorus retention index

Fertiliser

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<th>Type of fertiliser</th>
<th>Rate tonnes</th>
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Hay/silage

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<th>Year</th>
<th>Number of bales/rolls</th>
<th>Weight of bale/roll</th>
<th>Tonnes</th>
<th>Yield t/ha</th>
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</table>
Soil and tissue testing – why soil test?

Soils

Soil testing is probably the most effective way of assessing the fertility of your soils. Regular testing allows you to monitor the nutrient levels in the soil, warns you when acidity or salinity are likely to start affecting production and will help you develop a fertiliser program suited to your farm. It may help you identify what has gone wrong with a paddock. Use the record sheet on page 24 (Paddock Record 2) to record soil test results and fertiliser use. Record sheets are available from the Department of Agriculture and some soil testing firms.

Sample dryland pastures when the annual species have dried off – usually from December through to March. Sample your hardest setting soils first – especially clays which set hard once they dry out completely.

Sample irrigated pastures at the end of the irrigation season (March-April) or just before the season starts in September-October.

Sample at the same time each year: at least three months after the last fertiliser was applied.

Soil samples should be collected from the surface 10 cm of the soil – this is the standard which has been developed over the years in Western Australia. In some cases, it may be necessary to sample below 10 cm (subsoil acidity is a problem in some areas) and a separate sample should be collected.

If you are using soil testing as a monitoring tool, sample the same area at the same time each year. Mark the sampling area on your paddock map and stick to that area each time you sample.

If you are using soil testing to try and sort out a problem, sample both good and poor areas for comparison.

In either case, adopt a careful, methodical approach and make sure that the sample you collect is representative of the area being sampled.

**Do not mix soil types.** If a paddock contains substantial areas of different soils, sample them separately. If there is one major soil with small areas of different ones, only sample the predominant soil.

Collect 20-30 cores from each sampled area and bulk these together to make one sample. Scrape away surface organic material before collecting the core.

*Adopt a careful, methodical approach to soil sampling.*
Collecting the soil sample is the most unpleasant part of soil testing but the most critical. Various machines have been developed over the years to take some of the hard work out of it.

Machines are generally too expensive for one farmer to justify but they could be bought by a group of farmers or the work could be done on contract.

Interpreting soil test results is complex and you should discuss your figures with a Department of Agriculture development officer or consultant.

Figures from one year’s sampling can highlight areas of low fertility and suggest what may be needed in that year to correct the problem. Saline or acidic areas will be identified, allowing remedial action to be taken before you spend money trying to establish pasture.

Once you have been soil testing for a few years, you can use your records to work out the best fertiliser program for your farm. With information on pasture production over the seasons and your best estimate of the returns expected from the paddock, you can develop a fertiliser program which maintains the fertility of your soils and produces an economic return.

**Tissue testing**

Tissue testing is used as a guide to how well plants are taking up nutrients from the soil. It is particularly useful for diagnosing trace element deficiencies (see page 38, ‘Tissue test interpretation’).

In annual pastures, sample subterranean clover at early flowering – usually around August.

In irrigated pastures, sample white clover before heavy flowering has started. This is not always easy to judge and you need to be careful when interpreting results.

If you are using tissue testing to monitor nutrient uptake, collect the samples from a marked area – as for soil sampling.

If you are sampling to try and diagnose the cause of a problem, sample both healthy and unhealthy clover plants.

Where do the samples go?

A number of laboratories will analyse soil and tissue samples but not all provide an interpretation of the results.

Prices vary according to the number of samples and the number of nutrients tested. For current prices, contact the laboratory.
There are a number of different methods for chemical analysis of soil. For example, there are at least three techniques referred to as Colwell, Bray and Olsen for the analysis of soil for available phosphorus. Soil tests from different laboratories cannot be compared if different techniques are used.

Tables interpreting tissue and soil test results appear on pages 36 and 38.

### Soil testing laboratories

<table>
<thead>
<tr>
<th>Australian Agricultural Laboratories</th>
<th>Phosphorus test</th>
<th>Agro-Nutritional Research Laboratory</th>
<th>Phosphorus test</th>
</tr>
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<tbody>
<tr>
<td>(09) 345 3814</td>
<td>Colwell</td>
<td>(09) 444 6247</td>
<td>Bray,</td>
</tr>
<tr>
<td>3 Halley Road</td>
<td></td>
<td>2C Main Street</td>
<td>Colwell,</td>
</tr>
<tr>
<td>Balcatta 6021</td>
<td></td>
<td>Osborne Park 6017</td>
<td>Olsen</td>
</tr>
<tr>
<td>Chemistry Centre (WA)</td>
<td></td>
<td>Sheen Analytical Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>(09) 325 5544 or (09) 222 3177</td>
<td>Colwell</td>
<td>(09) 451 9388</td>
<td>Modified</td>
</tr>
<tr>
<td>125 Hay Street</td>
<td></td>
<td>41 Furnace Road</td>
<td>Colwell</td>
</tr>
<tr>
<td>EAST PERTH 6004</td>
<td></td>
<td>WELSHPOOL 6106</td>
<td></td>
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<tr>
<td>CSBP &amp; Farmers Ltd</td>
<td>Colwell</td>
<td>SGS Australia Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>(09) 279 5222 or (008) 01 9925</td>
<td></td>
<td>(09) 458 9666</td>
<td></td>
</tr>
<tr>
<td>2-6 Railway Parade</td>
<td></td>
<td>80 Railway Parade</td>
<td>Colwell</td>
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<tr>
<td>BAYSWATER 6053</td>
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<td>WELSHPOOL 6106</td>
<td></td>
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<tr>
<td>C.H. Bailey &amp; Son</td>
<td>Modified</td>
<td>(analysis done by Qantum Laboratories, Qld.)</td>
<td></td>
</tr>
<tr>
<td>(09) 592 1044 or (008) 01 9991</td>
<td>Colwell</td>
<td>Kingsley Agricultural Laboratory</td>
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</tr>
<tr>
<td>12 Hurrell Way</td>
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<td>(097) 61 7512</td>
<td>Colwell</td>
</tr>
<tr>
<td>ROCKINGHAM 6168</td>
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<td>RMB 382</td>
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<tr>
<td>AMDEL</td>
<td>Colwell</td>
<td>BRIDGETOWN 6255</td>
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</tr>
<tr>
<td>(09) 325 7311</td>
<td></td>
<td>Valley Laboratory Service</td>
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</tr>
<tr>
<td>154 Hampden Road</td>
<td></td>
<td>(097) 55 3626</td>
<td>Colwell</td>
</tr>
<tr>
<td>NEDLANDS 6009</td>
<td></td>
<td>25 Clarke Street</td>
<td></td>
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<tr>
<td>(analysis done in Adelaide)</td>
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<td>DUNSBOROUGH 6281</td>
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<tr>
<td>Analabs</td>
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<tr>
<td>(09) 458 7999</td>
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<tr>
<td>52 Murray Road</td>
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<tr>
<td>WELSHPOOL 6106</td>
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</table>
Fertilising the new pasture

Needs of new pasture

Improved pasture species and cultivars respond to higher levels of fertiliser than the species they replace. Thus Italian ryegrass responds to higher levels of nitrogen, phosphorus and sulphur than Wimmera ryegrass does. Clovers respond to phosphorus and potassium more than grasses – especially weed grasses. Subterranean clover produces effective nodules and grows best in soils with a pH (chloride) of 4.5 or higher. Lime is needed if the pH (chloride) drops below 4.3.

Tests to identify problems

Eliminate soil fertility problems by soil testing for phosphorus, potassium, acidity, salt and reactive iron or PRI (phosphorus retention index). Use the soil test results and soil type information to determine the rate and type of fertiliser and when to use it. The year before seeding, test the clover tissue for the trace elements copper (Cu), zinc (Zn) and if the test is available molybdenum (Mo). Land that originally had copper and zinc applied to it when newly cleared needs a further application after 15 years, especially if liming the soil. Molybdenum responsive soils need repeat applications of molybdenum every 10 years.

Early needs

In the establishment phase the most important nutrients are nitrogen (N) for the new grasses whether annual or perennial and phosphorus (P) for legumes. Potassium (K) and sulphur (S) are more important for spring growth.

Apply phosphorus at seeding and nitrogen at up to 30 to 40 kg/ha two weeks after seeding. More nitrogen may be needed in late winter/early spring. Apply potassium and sulphur as indicated by soil test and soil type. High fixing soils (loams, clays) need little or no sulphur, sandy soils generally have a high requirement for sulphur and potassium applied in late winter/early spring (see next section).

Broadcast or drill fertiliser with the seed. Drilling is most efficient on high fixing soils with a low phosphorus soil test. But high fertiliser rates drilled in with seed sown into sandy surfaced soils may reduce germination.

Drilling super or nitrogenous/phosphatic compound fertilisers with the seed, or in a band below the seed, may help the new pasture establish. Thus 75 kg DAP per hectare provides 13 kg nitrogen and 15 kg phosphorus per hectare (equal in nitrogen content to 28 kg urea and in phosphorus content to 160 kg superphosphate per hectare). Apply additional nitrogen three to four weeks after seeding.

Conventionally sown pastures benefit from nitrogen released from soil organic matter during cultivation, but direct drilled pastures do not. Therefore direct drilled pastures respond to higher levels of nitrogen (up to 10 to 15 kg N per hectare) than conventionally sown pastures.

Later needs for potassium and sulphur

Legumes require good supplies of sulphur and potassium to grow well in spring, form flowers and set seed. However, on sandy soils, sulphur (and potassium) deficiencies are common. Sulphate sulphur (found in superphosphate, gypsum, sulphate of ammonia) readily leaches out of sandy soils in winter. Waterlogging reduces uptake as well. Therefore pastures on sandy soils often need late winter applications of superphosphate or gypsum, especially if a low sulphur fertiliser was used at seeding. Apply potash at the same time to promote good spring growth by pasture legumes.

New pastures sown into cultivated soils may be difficult to fertilise in late winter. Sandy soils in this situation will need slow release forms of sulphur or higher rates of sulphate sulphur applied at seeding. Choose from elemental sulphur, crushed rock gypsum, Coastal Super or Summit Pasture. Superphosphate at 200 to 300 kg per hectare will supply enough sulphur but the excess phosphorus is wasteful and may contribute to environmental problems. Topdress muriate of potash six weeks after seeding sandy soils to minimise leaching.

Fertiliser types, rates and timing are dependent on soil type, soil test, enterprise profitability and what is practical. Use high rates of fertiliser in the establishment phase to ensure a good start to the pasture. Seek advice from a Department of Agriculture development officer.

Lime use

When soil pH (calcium chloride) falls below 4.3, lime is needed when reseeding. Common rates used are 2 to 3 tonnes ground limestone per hectare. Cultivate the lime in to the top 5 cm of soil during seedbed preparation.
Topdressing lime without cultivation delays the effect of the lime. Topdressed lime moves slowly through the soil. Compensate for this by drilling some of the lime in with the seed and use lime pelleted and inoculated seed.

Failure to apply lime to soils with a pH (calcium chloride) below 4.3 when reseeding often results in an unthrifty thin stand of clover. The clover may fail to nodulate and so suffer from nitrogen deficiency, producing pale green reddish leaves. The problem may not show in the reseeding year but in the following years, particularly if pelleted, inoculated seed is used.
Providing a range of services to the farming community.

- Soil and plant testing services.
- Agricultural Research.
- Field trials and field days.
- Country based Area Managers.
- Locally made fertilisers for WA conditions.
- Support for landcare groups.

For expert advice regarding fertiliser requirements for pasture improvement or soil and plant testing please contact your local CSBP Area Manager.

Ken Sharpe
Tel: (097) 31 7166

Stuart Cockerill
Tel: (09) 419 5753

Kim Rogers
Tel: (098) 41 5063

**Shires covered:**
Harvey, Dardanup, Capel, Busselton, Nannup, Augusta/Margaret River, Donnybrook/Balingup, Bridgetown/Greenbushes, Boyup Brook, West Arthur, Collie

**Shires covered:**
Waroona, Murray, Serpentine, Jarrahdale, Gingin, Victoria Plains, Boddington, Wandering

**Shires covered:**
Manjimup, Albany, Denmark, Plantagenet, Cranbrook, Tambellup

Wasfamers CSBP Limited ACN 008 668 371
Fertiliser strategies and tactics

The previous chapter discussed the fertiliser program needed when reseeding an individual paddock. The fertiliser program also needs considering in the context of the whole farm – its soil types, pasture types, pasture use – hay, silage or grazing – and the profitability of the enterprise. On many farms, fertiliser programs need designing so they minimise phosphorus and nitrogen losses to waterways and estuaries.

**Fertilising for maximum profit**

To fertilise for maximum profit, you need to understand the concept of diminishing returns with increased inputs. The response to an extra dollar’s worth of fertiliser declines as the fertiliser rate increases (see diagram). The fertiliser rate is at the optimum when an extra dollar’s worth of fertiliser produces an extra dollar’s worth of product. At this point you are fertilising for maximum profit.

The key to fertilising for maximum profit lies in regular soil testing of the whole farm. Soil testing enables you to put more fertiliser on paddocks low in nutrients and less fertiliser on paddocks high in nutrients. Use soil test monitoring strips to monitor changes in soil fertility. Use plant tissue tests to check trace element levels. Keep records of soil test results and fertiliser history. Seek advice from the Department of Agriculture, the soil testing service or a consultant. Most important, monitor your pasture’s health and productivity with a regular check of the pastures. Walk through the pastures. Use the hands and knees approach. Occasionally dig holes to check the soil condition and the roots.

**The soil type effect**

- Use higher rates of fertiliser on highly productive soil types.
- Unproductive soils need little or no fertiliser, e.g. high dry grey sands, salt scalds.
- High fixing soils (loamy gravels and red-brown loams) need more phosphorus than sandy loams and sands. Sulphur deficiency rarely occurs on high fixing soils. So high phosphorus, low sulphur analysis fertilisers may be used on these soils.
- Sandy soils need more potassium than loamy soils.
- Sulphur leaches readily out of sandy soils, particularly where there is more than 30 cm of sand over clay or gravel (e.g. deep, loose sands and deep, sandy duplex soils). Many sandy soils need regular (every year) applications of a sulphur fertiliser.
- Phosphorus leaches readily out of grey sandy soils. Some phosphorus remains in the soil forming a phosphate bank but if phosphorus fertiliser is withheld for a few years, the bank soon runs down.
- High fixing soils do not leach phosphorus and if regularly fertilised with phosphorus they

![Graph showing the relationship between Superphosphate cost and Gross margin.](image)

*Returns to investment in fertiliser decrease as maximum yield is approached. In this example, increasing fertiliser inputs from $20.00 to $40.00 returns a gross margin of $75.00. Increasing expenditure from $60.00 to $80.00 yields a return of only $12.00.*
build up a substantial phosphate bank. On these soils the phosphate bank runs down slowly.

**Pasture type**

- Legumes, clover, lotus and medics respond to higher levels of phosphorus, potassium and sulphur than grasses.
- Grasses, particularly the productive grasses, respond readily to nitrogenous fertiliser.
- Healthy legumes do not respond to nitrogenous fertiliser. If they do it may indicate poor root nodulation and/or a soil acidity problem or molybdenum deficiency.
- Italian ryegrass and perennial ryegrass growing on sandy soils respond to sulphur when fertilised with nitrogen. Use sulphate of ammonia at 150 kg per hectare (30 kg N/ha) or more. Sulphate of ammonia is the cheapest source of nitrogen and sulphur in combination and a valuable fertiliser on sandy soils.
- Pastures dominated by unproductive grasses, e.g. ripgut brome and silver grass, are not worth fertilising. Soil test, examine the soil, examine your management, find out what is wrong with the pasture or the soil.

**Pasture use and history**

- Apply more fertiliser, phosphorus, potassium, sulphur and nitrogen to hay and silage paddocks. Hay and silage cutting depletes the soil of nutrients which need replacing. Hay and silage crops are also more valuable than pastures grazed by beef cattle, so it pays to use higher fertiliser rates on hay and silage paddocks than grazed paddocks.
- Recently cleared paddocks have lower levels of phosphorus and higher levels of potassium than old paddocks.
- Newly laser levelled land will be low in phosphorus and may be more acidic than the undisturbed soil. Top soil saving reduces this effect.
- High analysis nitrogenous and phosphatic fertiliser use will lead to sulphur deficiency. It will occur in the first year on sandy soils but may take up to four years to become evident on red-brown loams and gravels.

**Timing**

- Pasture plants need phosphorus early in their life. It may be in the soil already or applied as fertiliser near the break of the season. On irrigation farms, apply phosphorus early in spring, three weeks before the first irrigation, or just after. Soil test irrigated pastures in autumn or early spring.
- Fertilise the high fixing soils (loams, gravels and clays) with phosphatic fertiliser at the break of the season in autumn. It pays.
- Fertilise sandy soils low in phosphorus with phosphatic fertiliser after the break of the season (May/June). This reduces leaching losses. Apply sulphate sulphur and potassium in August.
- Sandy soils with a good soil phosphorus status need not have an autumn dressing of phosphatic fertiliser. If practical apply maintenance dressings of phosphate with sulphate sulphur, and potassium in August, e.g. super potash.
- Apply nitrogenous fertilisers to dense ryegrass pastures in autumn two to four weeks after germination.
- Apply nitrogenous fertilisers to ryegrass based silage or hay crops between closing and six weeks before hay or silage cutting. Use 25 to 40 kg nitrogen per hectare.

**Economics**

- Soil testing allows you to increase the return on the fertiliser dollar.
- When funds are short consider reducing the fertiliser applied per hectare, but soil test first.
- Put more fertiliser on the most valuable crops and pastures, e.g. hay paddocks, milkers paddocks, paddocks grazed by growing stock, irrigated paddocks.
- An increased range of fertiliser types, and more firms supplying fertiliser, increases your opportunity to economise on fertiliser.

**Training**

Department of Agriculture development officers use Phosal-K, a computer model, to develop fertiliser recommendations. They also use the model with discussion groups to increase awareness of fertilisers and fertiliser strategies.

**Environmental issues**

Phosphorus leaching out of sandy soils and soil eroding from farm land in high rainfall areas are major contributors to the eutrophication and siltation of our estuaries on the west and south coasts. Many farmers are now conscious of this and have changed their fertiliser practice and other aspects of their management to reduce their contribution to the problem while maintaining or improving farm profit.
Measures used include:

- Soil testing to identify the nutrients actually needed to grow productive pasture.
- Changing to high sulphur, low phosphorus fertiliser programs more suited to sandy soils. Sulphur fertilisers now in use include Coastal Super, Summit Pasture, elemental sulphur or crushed rock gypsum for autumn application and superphosphate or fine gypsum in August.
- Changing fertiliser application time on sandy soils to after the break of the season to reduce nutrient losses by leaching.

- Streamlining – planting trees along streams to reduce erosion and act as a biological filter, absorbing nutrient laden water before it reaches the stream and discharges into an estuary.
- Some irrigation farmers now apply superphosphate after irrigating to reduce phosphorus loss in irrigation waters.

**Further reading**

- 'Farm budget guide' for fertiliser prices and analyses.
- Farmnotes and Bulletin (see below).

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<tr>
<th>Farmnote No.</th>
<th>Title</th>
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<tr>
<td>25/88</td>
<td>Copper, zinc and molybdenum fertilisers for new land</td>
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<td>92/84</td>
<td>Soil test and superphosphate rate</td>
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<td>105/91</td>
<td>Effectiveness of rock phosphate</td>
<td>541</td>
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<tr>
<td>103/88</td>
<td>Nitrogen deficiency in subterranean clover, medics and lucerne</td>
<td>137/632</td>
</tr>
<tr>
<td>77/86</td>
<td>Potassium deficiency in pasture legumes</td>
<td>137/632</td>
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<td>61/91</td>
<td>Sulphur deficiency in burr medic and subterranean clover</td>
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<td>Sulphur deficiency in subterranean clover</td>
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<td>88/85</td>
<td>Iron deficiency in subterranean clover</td>
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<tr>
<td>Bulletin 4228</td>
<td>Monitoring and managing soil acidity</td>
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# Soil Type Effect on Fertiliser Requirement

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<th>Soil Type</th>
<th>Phosphorus Requirement</th>
<th>Sulphur Requirement</th>
<th>Potassium Requirement</th>
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<td><em>Clays</em></td>
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<td>Nil to low</td>
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<td><em>Brown to black clays (Bungham clays)</em></td>
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<tr>
<td><em>Loams</em></td>
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<tr>
<td><em>Red to yellow-brown loams (karri/marri loams)</em></td>
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<tr>
<td><em>Loamy duplex soils (wandoo/marri/flooded gum loams)</em></td>
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<tr>
<td><em>Gravels</em></td>
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<tr>
<td><em>Yellow-brown gravelly loams (jarrah/wandoo gravels)</em></td>
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<tr>
<td><em>Red-brown gravelly loams (marri/karri gravels)</em></td>
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<tr>
<td><strong>Medium fixing soils</strong></td>
<td>Moderate</td>
<td>Moderate</td>
<td>Probable</td>
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<td><em>Loams</em></td>
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<tr>
<td><em>Grey-brown loams (marri/paperbark loams)</em></td>
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<tr>
<td><em>Gravels</em></td>
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<tr>
<td><em>Yellow-brown gravelly sands (jarrah/banksia gravels)</em></td>
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<td><em>Bleached (grey) gravelly sands</em></td>
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<tr>
<td><em>Sands</em></td>
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<td><em>Yellow-brown sands (jarrah sands)</em></td>
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<td><em>Shallow, sandy duplex soils (less than 30 cm sand over clay)</em></td>
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<td><strong>Low fixing soils</strong></td>
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<td><em>Bleached (grey) gravelly sands (jarrah/banksia gravel)</em></td>
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<tr>
<td><em>Sands</em></td>
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<td></td>
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<tr>
<td><em>Grey-brown sands (paperbark sands)</em></td>
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<tr>
<td><em>Deep, sandy duplex soils (more than 30 cm sand over clay)</em></td>
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<tr>
<td><strong>Very low fixing soils</strong></td>
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<td>Unprofitable to fertilise</td>
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<tr>
<td><em>Deep bleached (grey) sands (banksia sands)</em></td>
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NUTRIENT SOIL TEST STANDARDS

Use the tables below to help you interpret soil test results and make better use of your discussions with consultants and Department of Agriculture personnel. The optimum soil test level depends on enterprise profitability. Beef and sheep farms are less profitable than dairy farms so optimum soil test levels on beef and sheep farms are lower than on dairy farms.

<table>
<thead>
<tr>
<th>Nutrient status level</th>
<th>Response to fertiliser</th>
<th>Nutrient need</th>
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<tbody>
<tr>
<td>Low</td>
<td>Large growth response – over 15%</td>
<td>High nutrient need</td>
</tr>
<tr>
<td>Medium</td>
<td>Small growth response – about 15%</td>
<td>Maintenance dressings only</td>
</tr>
<tr>
<td>High</td>
<td>Little or no growth response</td>
<td>No economic need for fertiliser</td>
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<tr>
<td></td>
<td></td>
<td>Replace nutrient losses</td>
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1. Phosphorus status

<table>
<thead>
<tr>
<th>Phosphorus fixing level</th>
<th>Reactive iron* (ppm)</th>
<th>PRI*</th>
<th>Soil phosphorus levels (ppm)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
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<tr>
<td>Very low</td>
<td>1-100</td>
<td>Below 2</td>
<td>Below 7</td>
</tr>
<tr>
<td>Low</td>
<td>101-200</td>
<td>Below 2</td>
<td>Below 8</td>
</tr>
<tr>
<td>Low</td>
<td>201-400</td>
<td>2-7</td>
<td>Below 15</td>
</tr>
<tr>
<td>Medium</td>
<td>401-800</td>
<td>8-15</td>
<td>Below 20</td>
</tr>
<tr>
<td>Medium/high</td>
<td>801-1600</td>
<td>16-35</td>
<td>Below 25</td>
</tr>
<tr>
<td>High above</td>
<td>Above 1600</td>
<td>Above 35</td>
<td>Below 30</td>
</tr>
</tbody>
</table>

* Reactive iron and phosphorus retention index (PRI) are chemical tests used to measure the soil’s ability to hold or fix phosphate.

2. Potassium status

<table>
<thead>
<tr>
<th>Potassium levels (ppm)</th>
<th>Beef farms</th>
<th>Dairy farms, hay and silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium levels (ppm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low status</td>
<td>Below 80</td>
<td>Below 80</td>
</tr>
<tr>
<td>Medium status</td>
<td>80-100</td>
<td>80-120</td>
</tr>
<tr>
<td>High status</td>
<td>100+</td>
<td>120+</td>
</tr>
</tbody>
</table>

3. Sulphur status

Reactive iron and PRI both give a rough measure of the soil's ability to retain sulphur and, hence, its responsiveness to sulphur fertilisers.

<table>
<thead>
<tr>
<th>Reactive iron (ppm)</th>
<th>PRI</th>
<th>Sulphur retention</th>
<th>Sulphur response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-200</td>
<td>Below 2</td>
<td>Very low</td>
<td>33%+</td>
</tr>
<tr>
<td>201-400</td>
<td>2-7</td>
<td>Low</td>
<td>25-33%+</td>
</tr>
<tr>
<td>401-800</td>
<td>8-15</td>
<td>Medium</td>
<td>12-33%</td>
</tr>
<tr>
<td>801-1400</td>
<td>16-30</td>
<td>High</td>
<td>12-25%</td>
</tr>
<tr>
<td>1400-1600+</td>
<td>Above 30</td>
<td>Very high</td>
<td>Nil</td>
</tr>
</tbody>
</table>
Other factors are important too, e.g. depth to retentive subsoil, intensity of winter rain, fertiliser type. Sand over clay soils with the sandy layer 20 to 30 cm deep respond readily to sulphur. These soils usually have a low reactive iron (below 400 ppm) but they may have a medium reactive iron (400 to 800 ppm). Fertilise these soils in late winter with superphosphate, fine gypsum or sulphate of ammonia. Alternatively, use a slow release sulphur fertiliser in autumn.

4. Acidity
pH tested in calcium chloride (pH [CaCl$_2$]).

<table>
<thead>
<tr>
<th>pH (CaCl$_2$)</th>
<th>Below 4.3</th>
<th>Lime needed – especially if cultivating</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (CaCl$_2$)</td>
<td>4.3-4.5</td>
<td>Marginal need for lime</td>
</tr>
<tr>
<td>pH (CaCl$_2$)</td>
<td>4.5+</td>
<td>No need for lime</td>
</tr>
</tbody>
</table>

5. Salinity
**Effect of soil salinity (conductivity) on pasture production**
Salinity levels (in milliSiemens per metre) causing the following reduction in growth.

<table>
<thead>
<tr>
<th></th>
<th>Nil reduction</th>
<th>10% reduction</th>
<th>25% reduction</th>
<th>50% reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy soils</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clover</td>
<td>19</td>
<td>29</td>
<td>45</td>
<td>71</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>70</td>
<td>86</td>
<td>111</td>
<td>152</td>
</tr>
<tr>
<td><strong>Medium soils</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clover</td>
<td>13</td>
<td>20</td>
<td>32</td>
<td>50</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>49</td>
<td>61</td>
<td>79</td>
<td>108</td>
</tr>
<tr>
<td><strong>Light soils</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clover</td>
<td>8</td>
<td>13</td>
<td>20</td>
<td>31</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>31</td>
<td>38</td>
<td>49</td>
<td>67</td>
</tr>
</tbody>
</table>

Some laboratories (e.g. CSBP) use deciSiemens per metre (dS/m) – 1 dS/m = 100 mS/m.
**TISSUE TEST INTERPRETATION**

Nutrient levels for healthy subterranean clover growth on a dry matter basis. Grab samples of leaves and petioles (leaf stalks) taken at early to mid flowering and oven dried.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficient</th>
<th>Low/normal may be deficient</th>
<th>Adequate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen % N</td>
<td>-</td>
<td>-</td>
<td>3.0-5.0</td>
<td>Normal level</td>
</tr>
<tr>
<td>Phosphorus % P</td>
<td>Below 0.20</td>
<td>0.20-0.25</td>
<td>0.25-0.40</td>
<td>Very mobile in plant</td>
</tr>
<tr>
<td>Potassium % K</td>
<td>Below 1.00</td>
<td>1.00</td>
<td>1.0-2.0</td>
<td>Early to mid flowering</td>
</tr>
<tr>
<td>Sulphur % S</td>
<td>Below 0.18</td>
<td>0.18-0.2</td>
<td>0.2-0.3</td>
<td>Lowest in young leaves</td>
</tr>
<tr>
<td>Calcium % Ca</td>
<td>Below 0.18</td>
<td>0.20</td>
<td>0.4-1.0</td>
<td>Acidity symptoms develop first</td>
</tr>
<tr>
<td>Magnesium % Mg</td>
<td>Below 0.10</td>
<td>0.10</td>
<td>0.1-0.3</td>
<td>Rare in WA</td>
</tr>
<tr>
<td>Copper ppm Cu</td>
<td>Below 3</td>
<td>3.0-4.0</td>
<td>Above 4.0</td>
<td>Animals need greater</td>
</tr>
<tr>
<td>Zinc ppm Zn</td>
<td>Below 12</td>
<td>12-14</td>
<td>15-30</td>
<td>OK for animals</td>
</tr>
<tr>
<td>Manganese ppm Mn</td>
<td>Below 18</td>
<td>18-25</td>
<td>25-100</td>
<td>OK for animals</td>
</tr>
<tr>
<td>Iron ppm Fe</td>
<td>Below 100</td>
<td>100</td>
<td>Above 100</td>
<td>Rough guide</td>
</tr>
<tr>
<td>Molybdenum ppm Mo</td>
<td>Below 0.05</td>
<td>0.05-0.1</td>
<td>0.2-1.0</td>
<td>Costly analysis</td>
</tr>
<tr>
<td>Boron ppm B</td>
<td>Below 12</td>
<td>15-20</td>
<td>20-50</td>
<td>Rare in WA</td>
</tr>
</tbody>
</table>

**NUTRIENT LEVELS IN PASTURE FOR CATTLE AND SHEEP**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficient</th>
<th>Marginal</th>
<th>Adequate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt ppm Co</td>
<td>Below 0.07</td>
<td>0.07</td>
<td>Above 0.1</td>
<td>Plant critical level = 0.03</td>
</tr>
<tr>
<td>Copper ppm Cu</td>
<td>Below 4.0</td>
<td>4.0-5.0</td>
<td>5-10</td>
<td>Sheep levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0-7.0</td>
<td>7-12</td>
<td>Cattle levels</td>
</tr>
<tr>
<td>Selenium ppm Se</td>
<td>Below 0.01</td>
<td>0.01-0.03</td>
<td>0.03-0.1</td>
<td>See Note 3 below</td>
</tr>
</tbody>
</table>

**NB:**
1. Copper levels are for plants with normal molybdenum (0.5-1.0 ppm) and sulphur (0.2%) levels. At higher molybdenum and sulphur levels, higher copper levels are needed.
2. Where cobalt or copper levels are at healthy levels for clover but low for animals, rectify the deficiency by treating the animals or by fertiliser application.
3. Selenium levels in Western Australian pastures are often below the international standards listed above; yet selenium deficiency in livestock is rare and sporadic. Rectify selenium deficiency by treating animals or by fertiliser application.
Iron deficient subterranean clover leaflet showing interveinal chlorosis.

(Right) Severely sulphur deficient subterranean clover. Leaflets fold and stand erect and stems redden.

Healthy plants on the left; phosphorus deficient subterranean clover plants on the right.

Trikala subterranean clover leaves; healthy (left), mildly affected (centre) and severely affected (right) by potassium deficiency.
What legumes and grasses to sow?

Farmers have a wide range of pasture legumes and grasses suitable for different locations, climate zones and soil types to choose from. Detailed pasture variety recommendations are contained in Departmental Bulletins and Farmnotes – see, in particular, Bulletin 4299 ‘Pasture legume recommendations for sowing in 1995 and 1996’ and Bulletin 4238 ‘New developments in serradella’. This article summarises the Department of Agriculture’s recommendations on which legumes and grasses to sow.

Subterranean clover

The recommended subterranean clover cultivars suit Western Australian soils and climate and persist well. They are low in oestrogens and are highly resistant to the major fungal diseases, clover scorch and root rot. Many subterranean clover cultivars have varying degrees of resistance to virus diseases. The white seeded cultivars (Trikkala, Larisa, Meteor and Gosse) tolerate waterlogging.

South-west Western Australia has been divided into zones based on growing season length and annual rainfall. The over 700 mm rainfall belt includes the western margin of H4, H5 (south and west sections), VH3, VH4 and VH5.

High rainfall area

Zone H4. Seaton Park or the new variety York are recommended over most of this zone.

Along the western margin above 700 mm rainfall, a mixture of Goulburn and Trikkala should be used. Trikkala is also recommended in all waterlogged areas, either alone or in a mixture with Junee or Goulburn.

Zone H5. In most areas with less than 600 mm rainfall, Junee should be the basis of pasture sowings. East of Bremer Bay, Trikkala should be included with Junee.

Above 600 mm, a mixture of Goulburn and Trikkala is recommended, although Denmark or Gosse (or both) could be included in long growing season locations.

Trikkala, either alone or in a mixture with Goulburn, should be used wherever waterlogging occurs.

Rainfall zones based on growing season and annual rainfall
Very high rainfall area

Zone VH3. Junee and Trikkala are recommended throughout this zone. York can be included with Junee in drier areas or on poorer soils.

Zone VH4. A mixture of Goulburn, Trikkala and Gosse should be the basis of pasture sowings throughout this zone. On good soil types in the south-west of this zone, Karridale or Denmark can be included in the mixture. Where waterlogging is a problem, Trikkala or Gosse should be used. If waterlogging is patchy, include Goulburn, Denmark or Karridale.

For summer-wet areas, Palestine strawberry and Haifa white clovers should be included in the mixture.

Zone VH5. Karridale, Denmark and Gosse are recommended for sowing over the whole of this zone.

On the drier inland boundary of the zone, or on poorer soils, Goulburn should be included in the mixture.

In waterlogged areas a mixture of Meteora or Larisa could be included with Gosse and Denmark or Karridale. Meteora is preferred to Larisa where production of meadow hay is common and where the growing season is at least eight months. Palestine strawberry and Haifa white clovers should be included in mixtures for summer-wet areas.

**Characteristics of the recommended pasture legumes**

Brief details of the recommended pasture legumes are given in Table 1 below.

**Annual ryegrass**

Annual (Wimmera) ryegrass (*Lolium rigidum*) is still recommended throughout the area. It is the earliest maturing ryegrass completing seed development even in dry springs and regenerating readily the following autumn. However, repeated hay cutting reduces stand density. Wimmera also contains several ecotypes which can be manipulated by paddock management. Thus a grazing management/fodder conservation program that keeps the Wimmera in a vegetative phase encourages the development of a later maturing Wimmera ecotype.

Wimmera has a place on high rainfall farms, particularly on beef farms, but is being replaced, in part, by higher yielding, later maturing ryegrasses.

---

**Table 1. Characteristics of the recommended pasture legumes for high rainfall areas (above 700 mm)**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Species</th>
<th>Days from germination to 1st flower (Perth)</th>
<th>Hard seed*</th>
<th>Clover scorch*</th>
<th>Root rot*</th>
<th>Bluegreen aphid*</th>
<th>Redlegged earth mite*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seaton Park</td>
<td><em>T. subterraneum</em></td>
<td>110</td>
<td>2.5</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Trikkala</td>
<td><em>T. subterraneum</em></td>
<td>112</td>
<td>1.5</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Junee</td>
<td><em>T. subterraneum</em></td>
<td>124</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Gosse</td>
<td><em>T. subterraneum</em></td>
<td>126</td>
<td>2.3</td>
<td>8</td>
<td>8+</td>
<td>-</td>
<td>4-5</td>
</tr>
<tr>
<td>Goulburn</td>
<td><em>T. subterraneum</em></td>
<td>138</td>
<td>3.5</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Karridale</td>
<td><em>T. subterraneum</em></td>
<td>139</td>
<td>1.5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Denmark</td>
<td><em>T. subterraneum</em></td>
<td>142</td>
<td>1.5</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Larisa</td>
<td><em>T. subterraneum</em></td>
<td>142</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Meteora</td>
<td><em>T. subterraneum</em></td>
<td>148</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Madera</td>
<td><em>O. compressus</em></td>
<td>95</td>
<td>7</td>
<td>10</td>
<td>-</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Tatro</td>
<td><em>O. compressus</em></td>
<td>115</td>
<td>6</td>
<td>10</td>
<td>-</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Pitman</td>
<td><em>O. compressus</em></td>
<td>130</td>
<td>2</td>
<td>10</td>
<td>-</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

*Scale of 1 to 10 for degree of hard seedliness and resistance to clover scorch, root rot, bluegreen aphid and redlegged earth mite.
1 = little or no hard seed/little or no resistance
10 = high hard seed/high resistance
- = no information or not relevant.
Feed out with our 1994/95 model Kerry Sidewinder... No Hay/silage is wasted — all stock are fed — you save hay/silage, some say up to 30%

HAVE A LOOK AT THE KERRY SIDEWINDER'S NEW FEATURES

Heavy duty (cast iron tipped)
Forks now adjustable
for any size bale
(you won't spear the
next bale during pickup)

Roller carriage for
positive bale placement
All joints have grease
ripples

New silage/hay aggressive
(faster) feed out rollers
on both sides with deflector shield

New swivel hitch

Hydraulic hose holder

Chassis has been
strengthened right through
for silage/hay round bales

Floor bed support
strengthened substantially

New upgraded adjustable
head stock, handles any
size round bale

Not only is the 1994/95 model Kerry Sidewinder of heavier construction, the new spiked feed out rollers allow faster feed out times. A heavy duty hydraulic pump easily handles those big silage round bales.

OR

THE WOODS ROUND BALE UNROLLER

(Hay or Silage)

Our new heavy duty TPL model is designed for the biggest (and smallest) of bales. All sizes. Its unique design rolls the hay out on the corner of the bale, remote hydraulics not necessary. Ideal as a transporter! A budget priced machine.
The recommended later maturing ryegrass cultivars, Richmond, Surrey, Progrow, Conquest and Concord (in increasing order of maturity) out-yield Wimmera in autumn/winter and especially in spring (by up to 5 t/ha). Because they mature up to six weeks later than Wimmera they produce better quality silage and hay than Wimmera. Ensilage (at 10 per cent head emergence) and hay making (at 50 per cent head emergence) of these later maturing cultivars also occurs at a later and drier time in spring. This greatly reduces the risk of rain damage.

However, because they mature much later than Wimmera, the later maturing ryegrasses often do not persist, especially when cut for hay or grazed right through spring. Higher levels of persistence occur when the ryegrass is either grazed in spring or cut for silage and allowed to run up to seed in late October. In areas with a longer growing season they regrow after hay making and produce viable seed especially if the paddock is not grazed off after haymaking.

The later maturing ryegrass cultivars produce the highest yield of utilised feed when cut for hay or silage. Grow them on their own, in association with a tall growing, high spring yielding companion legume (e.g. balansa, shaftal, crimson clover) or with subterranean clover. If the ryegrass does not persist into the second year the pastures may need reseeding the following season.

**Alternative annual legumes**

Many annual legumes grow slowly in autumn/winter and then produce a very large spring flush. Therefore they are suitable for silage or hay production and make a good companion legume to a late maturing annual ryegrass.

Most alternative legumes have a high resistance to clover scorch and root rot. In common with subterranean clovers and serradellas, they are very susceptible to redlegged earth mite damage, especially in the seedling stage. They are all free of plant oestrogens.

**Balansa clover** (*Trifolium balansae*) (cultivar Paradana) grows well in spring even on mildly saline and waterlogged soils. By providing a good cover on saline land it reduces evaporation and, hence, reduces the spring salt rise. Balansa produces good quality, palatable hay and silage.

**Yellow serradella** (*Ornithopus compressus*) grows well in free drained, acidic, sandy soils. Its deep roots and fast seedling growth help it establish quickly on these soils. Two cultivars of yellow serradella are recommended for the above 700 mm rainfall zone – see Table 1.

- **Tauro** has midseason maturity and is recommended with Pitman for the above 700 mm rainfall zone. It has more winter vigour and higher seed yielding potential than Pitman. Tauro is more hard seeded than Pitman, but will regenerate in the first year after sowing.
- **Pitman** is a late maturing, hard seeded cultivar. The seed readily softens during the summer drought. It is suitable for the above 700 mm annual rainfall zone.

**Slender serradella** (*Ornithopus pinnatus*) has finer leaves and stems than yellow serradella and tolerates waterlogged soils. The only cultivar, Jebala, flowers three days later than Tauro. It is very hard seeded (hammer milling the pods to break them up will increase the germination percentage). There is no seed certification scheme for Jebala.

**Persian clover** (*Trifolium resupinatum*) is well adapted to alkaline, waterlogged soils but also grows under mild, acidic conditions. Two cultivars are available:

- **Maral** is late maturing and soft seeded (and, therefore, has poor persistence/regeneration).
- **Kyambro** has a medium to late maturity with high levels of hard seed.

**Arrowleaf clover** (*Trifolium vesiculosum*) is well adapted to a wide range of soil types provided they are well drained. It grows deep roots and matures late, two characteristics which give it an advantage on soils with subsurface moisture in spring. Arrowleaf clover has very hard seeds.

**Perennial legumes**

**White clover** (*Trifolium repens*) grows on a wide range of soil types and is recommended for irrigated pastures and summer moist areas. It is the most nutritious plant available for these pastures. It grows throughout the year but mainly in spring/early summer with mid spring growth rates reaching 150 kg/ha/day. Summer growth rates are limited by very high temperatures and moisture stress whilst low temperatures and waterlogging limit winter growth rates.

- **Haifa** is the recommended cultivar for irrigated pastures. In a recent three year irrigated pasture trial at Wokalup Research Station the cultivars Kopu and Espanzo grew and persisted well.
Strawberry clover (*Trifolium fragiferum*) (cultivar Palestine) is well adapted to mildly saline and waterlogged soils and has a useful degree of summer drought tolerance. Strawberry clover is recommended as part of the mix for irrigated pastures on saline soils and summer moist pasture swards.

Both white and strawberry clover spread by stolon (runner) colonisation and by seed in dung.

Lucerne (*Medicago sativa*). Traditional cultivars will grow well in free drained, neutral to alkaline soils under summer irrigation.

On non irrigated land, lucerne needs an eight month growing season or a perched water-table in shorter growing season areas. On non irrigated land grow lucerne alone or with a perennial grass, e.g. Currie cocksfoot.

**Perennial grasses**

Two types of perennial grass can be sown on south-west farms.

- **Winter active/summer dormant** perennial grasses include perennial ryegrass, phalaris, cocksfoot and tall fescue. They are grown with annual legumes, annual ryegrasses and sometimes lucerne. A good stand of perennial grass contains 50 plants/square metre.

- **Summer active/winter dormant** perennial grasses grow under irrigation or on summer moist land. They include, kikuyu, paspalum, couch, Rhodes grass and perennial veldt grass.

Perennial ryegrass also produces well under irrigation and on summer moist land. High temperatures do slow growth in mid summer but it produces well in autumn, winter and spring. Winter active perennial grass pastures produce and persist well in areas with above 750 mm rainfall and an eight month long growing season (areas south of a line from Busselton, Lake Muir, Mt Barker and Cape Riche). Soil types with a perched water-table in the top metre are preferred.

Recommended species include perennial ryegrass, phalaris, cocksfoot and tall fescue.

**Perennial ryegrass** does best on summer flats. It is the least drought tolerant of the perennial grasses, has some waterlogging tolerance and produces the highest quality feed. It is less useful on hillslopes than other perennial grasses.

**Tall fescue** has better drought tolerance than ryegrass but not as good as cocksfoot and phalaris.

The cultivar Au Triumph persists better than Demeter.

**Cocksfoot** establishes readily and has a high degree of drought tolerance. Currie is the most persistent and productive cultivar.

**Phalaris** cultivars vary in their seedling vigour. Once established phalaris will persist for many years. Australian is the most persistent.

Phalaris can be toxic. Phalaris staggars is associated with cobalt deficiency in sheep. Phalaris poisoning can be minimised by maintaining a good legume balance in the sward.

Many perennial grass cultivars are currently being evaluated in small plot trials and paddock evaluation in a Meat Research Corporation funded project. See Bulletin 4253 ‘Perennial pastures for areas receiving less than 800 mm annual rainfall’ for good descriptions of the different varieties and cultivars.

**Summer active perennials**

Kikuyu, paspalum and perennial ryegrass are the dominant companion grass species in irrigated pastures. Ryegrass is the most nutritious and suitable cultivars for irrigation include Ellett and Embassy. (See also the chapters on ‘Renovating irrigated pastures’ and ‘Irrigated pasture management’). However, perennial ryegrass cannot tolerate moisture stress or high temperatures as well as kikuyu and paspalum.

On dryland, kikuyu produces useful amounts of green feed during the summer drought. Couch can too, but it is less productive than kikuyu and grows on poorer soils. This feed is usually of higher quality than dry, summer pasture residues and so improves animal productivity over summer. Feed quality, however, depends on pasture management (see Farmnote 11/95 ‘Kikuyu – the forgotten pasture’).

Undergrazed kikuyu and couch may develop into dense stands of tussocky pasture that smoother annual pasture species, thus reducing paddock productivity.

**Pasture mixtures**

Sow grass/legume mixtures on virgin soils, newly lasered land, after cropping and when renovating run-down pasture. Sow a variety of clovers suited to the soil type with one, two or three grass cultivars.

Sometimes all that is needed is to add grass to a good stand of clover – or vice versa.
Establishment and persistence of the sown varieties depends on good management before sowing, the sowing technique and good after-sowing management.

**Seeding rates**
Subterranean clover: 10 to 15 kg/ha.
Serradella: 3 to 4 kg/ha of dehulled seed.
Balansa and other small seeded alternative clovers: 2 kg/ha.
Ryegrass: 5 to 20 kg/ha.
Lower rates when part of a mix.
Medium rates when resowing single variety stands.
*Higher rates for high production stands of late maturing, annual and irrigated pastures.*

Cocksfoot: 3 kg/ha.
Phalaris: 3 kg/ha.
Tall fescue: 5 to 10 kg/ha.
Perennial ryegrass: 5 to 7 kg/ha.

**Irrigated pasture mix**
Embassy perennial ryegrass: 5 kg/ha.
Ellett perennial ryegrass: 5 kg/ha.
Concord annual ryegrass: 7 kg/ha.
Haifa white clover: 2 kg/ha.
Kopu white clover: 2 kg/ha.
Palestine strawberry clover: 1-2 kg/ha (in saline areas).
Plant species for particular soils

**Most soils**

**Annual legumes**
- subterranean clover, balansa clover, serradella, arrowleaf clover.

**Perennial legumes**
- white clover, strawberry clover, lucerne (with lime).

**Annual/perennial grasses**
- most grasses.

**Salty soils**

**Highly saline**
- tall wheat grass, puccinella, salt water couch (*Paspalum distichum*).

**Moderately saline**
- tall wheat grass, Rhodes grass, paspalum, Wimmera ryegrass, perennial ryegrass, phalaris, tall fescue, couch, kikuyu, strawberry clover, lotus and balansa clover.

**Slightly saline**
- as for moderately saline soils, plus Trikkala. Gosse, Larisa and Meteora subterranean clover.

**Waterlogged soils**
White seeded subterranean clovers (Trikkala, Gosse, Larisa, Meteora). Slender serradella (Jebella), strawberry clover, lotus, balansa clover, phalaris, tall fescue, kikuyu.

**High dry sands**
Dalkeith subterranean clover (not in scorch prone areas), serradella (Pitman, Tauro), Wimmera ryegrass, WA blue lupins, tagasaste, *Acacia saligna*.

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**Further reading**

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Perennial pastures – their role and establishment

Perennial grass based pastures are well suited to the higher rainfall zones in the south-west and southern coastal areas of Western Australia. Because of their deep root system, perennials are able to remain green later in spring than an annual pasture. Perennial growth begins early in the autumn, because the root system is already established. They are also capable of producing green feed in response to summer rainfall; in annual pastures, summer rainfall would mean a rapid decline in quality of dry residues.

Productivity

Production benefits from perennials compared with annuals, are usually attributable to improved performance over summer/autumn. Animals grazing well established stands of perennials maintain, or in some cases improve condition far better than those grazing annual pastures. This often means that animals are ready to be turned off in spring well before those grazing annual pastures. This has been demonstrated in large scale grazing trials at Manjimup (based on cocksfoot) and at Mt. Barker (based on cocksfoot, tall fescue and phalaris). There is also a significant reduction in supplementary feeding requirements in beef enterprises.

Sustainability

Perennials offer a stable pasture base across seasons. In annual pastures, a wide range of composition changes is found, largely dependent on the timing of the break of the season, and management in the previous year. Perennials are not readily invaded by weeds, and when well established retain a desirable mix of annual legume and perennial grass.

Work in the eastern States has also shown that rates of topsoil acidification are reduced under perennials when compared with annual pastures. The long growing periods of the deep rooted perennials (late spring, after summer rain, at the break of the season) reduce nitrate leaching, and acidification rates.

Further, the long growing period, results in increased transpiration. Perennials continue to use water when annuals are dead. Drying out soil profiles over summer/autumn means that winter waterlogging takes longer to occur than on annual based pastures.

There are also soil stabilisation benefits from a permanent soil binding root mass that prevents wind and water erosion.

Establishing perennials

Perennial pastures cost more to establish than annual pastures, because of the increased cost of the grass component (annual legume the same), and the increased need to reduce stocking pressures in the year of sowing. This expense, and the fact that very little reseding from perennial grasses occurs, makes it essential to plan the renovation program well.

The key factors in establishing perennials are weed control, sowing time and method, grazing management, insect control and nutrition.

Weed control

Weed control is critical to the success of a resowing operation. Perennial grass seedlings are usually slower growing than weeds - and need protection if they are to develop into strong plants. Strategies to control weeds should be in place well before the year of sowing, and will vary depending on weed types and mixes.

Common methods of grass control in the year prior to sowing include spray-grazing (usually in winter) or pasture manipulation, spray-topping in spring to reduce seed set, hay cutting to remove weed seeds, and heavy grazing pressure to prevent seed set. Broad-leaved weed control can best be achieved during a cropping phase, where cropping is an option, or through spray-grazing (very effective for capeweed control). With a further weed kill in the year of sowing, by cultivation or through chemical means, weed problems should be minimised.

Time of sowing

Time of sowing will vary among perennials. Generally, the temperate perennials such as perennial ryegrass, cocksfoot, tall fescue and phalaris are best sown following the break of season. This allows a full growing season for the development of strong crowns, before the onset of the hot dry summer. These are, however, circumstances where autumn sowing may need to be postponed. Tall fescue germination will be reduced by cold temperatures – and should not be sown in late break situations. Sub-tropical species such as kikuyu, paspalum and couch require high soil temperatures to germinate and grow, and as such need to be sown in spring.

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Sowing methods
Sowing methods are aimed at placing the small seed accurately about 1 cm below the soil surface, in an environment conducive to optimal growth. This can be achieved by several means, and will vary depending on machinery available. Inverted T shaped tines have proven very successful – and can be used via specialist pasture seed drills, or can be fitted to a range of existing seeding machinery.

Grazing management
Grazing management is a complex matter, and needs to be better understood for a range of species. However, experience has clearly shown the benefit of lax grazing during the first spring of a perennial grass. Winter grazing may be advantageous in controlling any surviving weeds, but stock should be removed by spring. After pastures have senesced, summer/autumn grazing is recommended to remove the bulk of pasture residues generated from lax spring grazing. This residue will often retain some greenness and represents a valuable feed source – a credit against the costs of establishment. However, a close watch should be kept to ensure perennial plants are not selectively grazed and uprooted. Second year grazing pressures will be largely dependent on seasonal conditions. If seasonal conditions are adverse, some protection may still need to be given to perennial plants to ensure strong crown development. Favourable conditions will see a resumption of normal or increased stocking rates.

Grazing management will vary among species and will depend on factors such as growth patterns and habits. The controlled grazing management technique described in the chapter on ‘Grazing systems and pasture management’ (page 71) appears applicable to perennial ryegrass. The latest phalaris varieties are winter active – and if overgrazed at this stage will not persist. Phalaris has also been shown to benefit from spring deferment - which normally occurs during the spring flush. More specific grazing management recommendations need to be developed for different species to optimise both plant and animal production. However, in general, the overgrazing of perennial crowns during periods of stress is likely to reduce perennial plant density.

Insect control
Insect control is important in protecting the slow growing grasses. The more stress imposed on a plant, the lower the chance of survival. Of most concern during the early life of perennial pastures are redlegged earth mite. They damage emerging grasses as well as legumes, and as such need careful monitoring. Control is relatively cheap – and quick to apply using a mister.

Nutrition
Nutrition of perennial pastures will be similar to that of annuals. It is advisable to ensure that nutrition is adequate – through soil or plant testing. When sowing perennials, however, there is a danger in using nitrogen at seeding. If weed control has not been excellent, the faster growing weeds will respond far quicker to the nitrogen than the perennials for which the nitrogen had been targeted. It is better to apply nitrogen at a later stage, when perennial root systems have developed, and can compete more effectively for the applied fertiliser.
Effective weed control

Assess the problem first
Weeds readily swamp a newly seeded pasture and must be controlled when reseeding. Effective weed control depends on a thorough assessment of the weed problem in the year before reseeding. Are there hard-to-kill weeds present, such as dock, sorrel or doublegee? Are annual grasses or capeweed a problem?

The year before reseeding
Start weed control the year before you reseed. Pasture topping, hay freezing and spray-graze (see separate chapters) are essential parts of the weed control program. Hard grazing with sheep controls many broad-leaved and grassy weeds. Alternatively, many hard-to-kill weeds, such as dock and sorrel, can be controlled by cropping the paddock with oats or ryegrass for hay the year before seeding. Weeds are controlled in-crop and the profit from growing the crop offsets the cost of pasture establishment (see chapter on ‘Fiddle dock’, page 85).

Annual grasses (silver, barley, and brome grass) need particular attention. Most grass seeds germinate in the year following seed set. Staggered germination causes further problems. Control annual grasses the year before seeding by reducing seed set by pasture topping, hay freezing or hard grazing. Pasture manipulation with herbicides in autumn also has a place. (See ‘Weed control after seeding’ later in this chapter and ‘Barley grass’, page 82). If reseeding, control Wimmera ryegrass and replace with a more productive ryegrass.

Pasture topping also helps control capeweed, sorrel and Guildford grass.

Use spray-graze to control broad-leaved weeds the year before reseeding and after reseeding.

The reseeding year - before seeding
Graze off the dry pasture residue before the break of the season in autumn. Make sure that the feed is short – less than 25 mm high, when the season breaks.

Direct drilling before the break ensures early establishment and minimum loss of feed. Avoid failure caused by false breaks by sowing just before the normal break.

When seeding after the break encourage a full germination to enable a good weed kill before seeding.

Consider ‘tickle’ cultivating the soil before the opening rains. Then wait until the paddock has ‘greened up’ with a full germination before killing the weeds.

Spray with herbicide and direct drill whenever possible. Cultivation encourages weed seeds to germinate, but see points for and against direct drilling in the ‘Direct drilling’ chapter.

Two weeks after the ‘break’ inspect the paddock for hard-to-kill perennial weeds, such as established sorrel and dock. Treatment of the paddock will depend on the presence or absence of these weeds.

Until a full germination has occurred keep annual weeds small by continuous grazing. This ensures an easier kill with lower herbicide rates and low trash levels when sowing.

If rain is expected remove stock to prevent trampling and mudding of weed leaves. Spray a few days after the rain falls, when the weeds have made some recovery from grazing.

Use one of the following spray programs.

a) If direct drilling, spray with glyphosate (450 g/L) at 600 mL/ha (annual weeds) to 1 L/ha (perennial weeds) plus 100 mL of Goal®/ha and follow up one week later with 600 mL of Spray.Seed® to complete the kill. Seed immediately after spraying with Spray.Seed®.

b) If seeding conventionally apply 600 mL to 1.2 L of glyphosate (450 g/L) plus 100 mL of Goal®/ha and wait one week before cultivating. The rate depends on the type and maturity of the weeds. Perennial and more mature weeds require heavier rates.

c) Use glyphosate at higher rates without Goal®.

Use sufficient herbicide, in accordance with label recommendations, to achieve a total weed kill.

Always include a bare soil active insecticide (endosulfan or high rates of methidathion) for redlegged earth mite control with the final herbicide application before sowing and watch for insect damage at and after germination.

If you use herbicides, always read the label, wear protective clothing and calibrate your spray boom, or use a contractor.
Weed control after seeding

Conventional seed bed preparation and sowing is described in a later chapter.

The weed control strategies needed to control weeds in newly seeded pastures, depend on the weeds present, their density and the desired pasture composition.

Grazing four to six weeks after seeding gives good control of many weeds, particularly broad-leaved weeds such as capeweed, doublegeec, thistle and wild radish. Grazing at this time – at about the 3½ leaf stage of ryegrass – retards weeds and encourages the development of a vigorous, well balanced, competitive pasture.

Graze the pasture – preferably in rotational manner – throughout the growing season to complete the task (see chapter on ‘Grazing systems and pasture management’, page 71).

Control slender thistles by allowing them to reach 100 mm high, then graze them heavily (see chapter on ‘Slender thistle’, page 91). If you cannot defer grazing this long, use the spray-graze technique instead.

Spray-grazing with 2,4-D amine, MCPA or Medcamine® (details in the next chapter), controls many broad-leaved weeds – capeweed, thistles, doublegeec, wild radish, turnip and Paterson’s curse. It reduces old man dock by 20 to 60 per cent. The cost, using 500 mL to 1.4 L/ha of 2,4-D amine, is $2.50 to $7.00/ha. Spray-grazing works better with sheep than with cattle.

Reglone® at 350 mL/ha (cost = $4.76) with no surfactant, gives good control of capeweed and erodium (corkscrew) with temporary setback to ryegrass and slight damage (some spotting) to clover. Spray when the clover has three trifoliate leaves and the capeweed is no more than 10 cm in diameter.

Jaguar® at 350 to 500 mL/ha (cost = $7.20 to $10.25/ha), controls wild radish, wild mustard, capeweed, doublegeec and Paterson’s curse in clover. Apply when clover has at least three trifoliate leaves. Expect some damage to clover at 500 mL/ha.

2,4-DB at 2-4 L/ha (cost = $16.70 to $33.40/ha), controls young actively growing weeds without damaging clover. The commercial products include Buticide®, Davison 2,4-DB400® and Legumex®.

Tribunil® at 700 to 850 g/ha (cost = $29.70 to $36.00/ha), controls seedling capeweed, doublegeec, mustard, radish and turnip in clover pastures.

To control silver grass use simazine at 250 g to 500 g active ingredient/ha (500 mL to 1.0 L/ha of 50 per cent product). The cost at these rates is only $2.60 to $5.20/ha. Use lower rates on sandy surface soils. Paddocks with a low clover density (less than 30 per cent clover) may look bare after grass removal. Spray any time after clover has three or four trifoliate leaves. Simazine is a root translocated herbicide. It needs rain to activate it.

A mixture of 500 mL/ha simazine (50 per cent) plus 500 mL/ha paraquat controls silver, brome and barley grass and erodium, with moderate control of capeweed.

Kerb® and Carbetamex® are root translocated herbicides and control grasses including silver grass and ryegrass very effectively, but they cost between $100 and $200/ha.

The foliar translocated, grass selective herbicides include Verdict®, Targa®, Fusilade®, Sertin® and Hoegrass®. They cause little damage to clovers. They also control ryegrass – especially Sertin®. Fusilade® at 125 mL/ha controls brome grass with variable damage to ryegrass. They cost $15 to $20/ha.

More detailed articles on the control of the most important weeds are found towards the end of this manual.
The spray-graze technique

The spray-graze technique selectively controls broad-leaved weeds using sub-lethal rates of MCPA, 2,4-D amine or 2,4-DB combined with heavy grazing.

Advantages

- No permanent damage to established pasture legumes.
- Cost saving in the amount of herbicide used.
- Environmentally sound owing to low rates.
- No effect on grasses – selective.

Timing

Apply the herbicide when the weeds are actively growing and in the small rosette stage. This occurs six to eight weeks after the break of the season. Clover damage will be minimal if it has at least two to three leaves.

For late winter/early spring treatments (usually a second spray-graze) keep the paddock well grazed during the winter. Apply the herbicide before the clover flowers.

Grazing

Stock the paddock two to three days after spraying at 8-10 times the normal stocking rate to selectively graze the weeds close to the ground. Grazing by sheep is preferred because of their close cropping habit, but is not essential.

Graze for two to six weeks, removing stock before the pasture is damaged (i.e. at 3 to 5 cm high or 800 to 1000 kg residual dry matter). Spray mature weeds at heavier rates in addition to grazing for best control.

Why the technique works

The sub-lethal rate of herbicide will not kill the weeds on its own. The herbicide is absorbed by the weeds causing them to assume a more erect habit, allowing for easier grazing. Palatability increases as the plants wilt and sugar levels rise after spraying.

If the weeds are not heavily grazed, most will recover after about three weeks. Regrowth usually survives. Following treatment, the pasture makes normal growth, which competes strongly with the weeds.

Pitfalls

For best chemical control, weeds must be small and actively growing. Avoid stress caused by waterlogging or frost. Allow at least seven days after heavy frosts before spraying.

Heavy stocking pressure is critical. Animals may lose weight to achieve the aim of really heavy grazing. Large paddocks cause difficulties in achieving desired grazing pressure.

Weeds controlled

Wild radish, turnip, mustard, capeweed, thistles, doublegee, dock and Paterson’s curse are controlled by spray-grazing.

Herbicides and application rates

<table>
<thead>
<tr>
<th>MCPA</th>
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<th>2,4-D amine</th>
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<tr>
<td>250 g/L</td>
<td>500 g/L</td>
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<tr>
<td>Rate/ha</td>
<td>Rate/ha</td>
<td>Rate/ha</td>
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<tr>
<td>700 mL-2.8 L</td>
<td>500 mL-1.4 L</td>
<td>500 mL-1.4 L</td>
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Medicamone®, a mixture of MCPA and 2,4-DB, is also used to spray-graze subterranean clover pastures (rate 700 mL to 1.4 L/ha).

The several preparations of 2,4-DB 500 g/L and 400 g/L may also be used for spray-graze (e.g. Trifolamine®, Buticide®, Legumex®).

Do not spray if rain is likely within four hours.

Warning: In districts where commercial vineyards or tomato crops are within 5 to 10 km, use only amine or low volatile ester formulations of these herbicides. The restrictions apply to all hormone herbicides, i.e. MCPA; MCPB; 2,4-D; 2,4-DB; dicamba; 2,4,5-T and picloram.

If using an amine formulation within 5 km radius of a vineyard or tomato crop obtain a permit from the nearest office of the Department of Agriculture. Low volume ester formulations cannot be used within 5 km. Be careful with pastures dominated by Paterson’s curse, variegated thistle or capeweed; spray-graze increases their palatability and may cause stock poisoning due to excessive intake of toxins.
**Pasture topping**

Pasture topping with glyphosate or paraquat, or hay freezing with glyphosate, are the most important year-before weed control techniques in preparation for reseeding pastures.

Topping involves the application of low rates of herbicide after head emergence to prevent the formation of viable seed in annual grass weeds and capeweed without destroying the available feed.

Hay freezing involves the same principles as pasture topping. Higher rates of herbicide are applied two to four weeks earlier to stop further growth of the pasture.

**Why pasture top or hay freeze?**

1. Reduce weed seed levels
   
   The number of annual grass seeds in the soil can vary from 2000 to 60,000/square metre. Unless seeding is reduced in the previous year, a 90 per cent germination with the autumn break still leaves large numbers to germinate after sowing and compete with the pasture seedlings.

   **Note:** Density of sown grass seed is only about 300 seeds/square metre.

2. Improve feed quality
   
   Palatability and use are increased, resulting in greater meat, milk and wool production and profit. Untreated pastures have lower feed value and palatability and are not as well grazed.

3. Reduce grass seed problems
   
   Grasses, such as barley grass and rip gut brome, have long, sharp awns that injure stock. Contaminate wool and make hay difficult to handle. Pasture topping largely eliminates these problems.

4. Reduce trash and sowing problems
   
   Low trash levels reduce insect shelter, insect survival, fungal disease carryover and trash build up on sowing machinery.

5. Promote more complete weed germination in autumn

6. Low cost, less than $10/ha

**How to pasture top**

1. Timing is critical
   
   Apply glyphosate at early head emergence (50 per cent heads emerged). Apply paraquat after complete head emergence and before the oldest heads begin to hay off. The two herbicides provide a 2-3 week window for effective spraying.

   **Apply glyphosate at early head emergence (a) when 50 per cent of heads have emerged. Apply paraquat at full head emergence (b) but before the heads hay off.**

2. Even head emergence
   
   This is the other essential factor for effective topping. Begin grazing the paddock over the winter and keep it well grazed, i.e. no more than 25 mm high. Graze heavily through spring until the soil begins to dry out and the days are warm to hot, sometime between late September and early November. Once stock are removed all grasses will rapidly run to head.

3. Surfactant
   
   Low herbicide rates mean extra wetting agent must be added at 200-300 mL/100 L of spray volume.

4. Rates
   
   240-360 mL/ha glyphosate (450 g/L), 300-450 mL glyphosate (360 g/L) or 500 mL/ha paraquat (200 g/L).
5. Redlegged earth mite control
   Addition of a miticide to the topping/freezing herbicide is strongly recommended. This will reduce the population that lays eggs over spring and so lower redlegged earth mite numbers the following autumn.

6. Grazing
   Grazing is essential to capitalise on the benefits of topping.
   Graze soon after spraying with paraquat as feed value begins to decline after spraying.
   Feed quality is preserved for up to two months, if glyphosate is used. Start grazing after about 21 days, when the palatability of the feed reaches a peak.

**Hay freezing**

In some situations it may be difficult to achieve even head emergence, either because of mixed annual species, or insufficient grazing pressure. Heavier rates of glyphosate at full head emergence of the earliest flowering plants will effectively control seeding of the entire sward. Use 750 mL to 1.25 L of 360 g/L product or 600 mL to 1 L/ha of 450 g/L product.

Graze the pasture heavily in springtime, then remove the stock to allow pasture recovery before spraying.

The spraying will kill most of the grass weeds and significantly reduce the seed set of clovers and the hard-to-kill weeds, such as erodium.

Any recovery of weeds can be controlled by grazing during the late spring, summer and autumn.

Retain at least 25 mm of ground cover over the summer-autumn period to prevent soil erosion by wind and thunderstorms.

**Broad-leaved weeds**

Glyphosate applied at flowering time controls capeweed seeding.

Sorrel is often the worst broad-leaved weed in reseeded pastures and can reduce the establishment of pasture seedlings. It can be controlled during pasture topping or freezing by the addition of 5 g/ha of Renovate® to the glyphosate.

Eliminate Guildford grass by adding Glean®, Siege® or Renovate® at 10-15 g/ha.

**Note:** Ally®, Glean® and Siege® must be dispersed in the tank before adding glyphosate.

Ally®, Glean® and Siege® will kill clovers, so only use these herbicides when a large seed bank exists or you definitely plan to resow clover next autumn.

Glyphosate (450 g/L) and paraquat (200 g/L) are produced by several firms in many formulations.

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*Hay freezing preserves feed quality (a) protein, (b) dry matter digestibility.*
The seeding operation

Objectives

The objective is to establish a dense, vigorous and productive sward composed of desirable pasture species. Achieve this objective by sowing early – near the break of the season, into a fine, firm seed bed. Control weeds, pests and diseases.

A good seeding operation causes little erosion, maximises grazing opportunities in the first year and successfully establishes a dense pasture.

Advantages of early seeding

Sow pastures as early as possible so the pasture establishes in warm weather and produces a strong vegetative base. The pasture will then grow well in winter and spring and have time to produce plenty of seed for regeneration the next year.

Time of sowing is a compromise between sowing early to maximise dry matter production and seed production and delaying sowing for a more complete weed kill and for better soil conditions for seeding and germination. The compromise depends mainly on the expected weed challenge and your own weed control skills.

Integrated weed control

Start the weed control program the year before seeding. Know your weed challenge (species, numbers) and plan your weed control strategies appropriately.

Weed control strategies described in weed control articles include:

- cropping with cereal hay or ryegrass the year before seeding to allow in-crop spraying of problem weeds (dock, sorrel);
- spray-graze;
- hay freezing and pasture topping.

Hard grazing the year before seeding also controls weeds, particularly grasses and capeweed. Sheep are more effective than cattle at hard grazing. Herbicides reinforce good grazing management.

Heavy grazing or burning over summer, within erosion limits, removes some seed. Burning works well with barley grass.

A shallow cultivation (autumn tickle) near the break, just before germinating rains, stimulates a quick germination. When germination is complete, cultivate or spray with herbicide. Cultivation may bring more seed into the surface layer and stimulate another germination, therefore spraying is preferred. Sow the pasture with a minimum disturbance seeding operation. Graze six weeks after seeding to control broad-leaved weeds.

Pest and disease control

Redlegged earth mite is a particularly serious pest of new sown pastures. Chemical control of redlegged earth mite in new sown pastures is essential in most seasons (see chapter on ‘Pasture pests’, page 67).

Clover scorch, root rots and viruses are the main diseases of pasture legumes. The main control weapon is to sow resistant varieties (see chapter on ‘Diseases of annual pasture legumes’, page 64).
Conventional pasture establishment

Graze dry feed down to 25 mm to encourage weed germination and make cultural operations easier.

Cultivate the soil with a plough, disc cultivator, scarifier or other tined implements to prepare a fine, firm, seedbed and kill weeds. A fine tilth ensures an even and rapid germination of pasture seeds. The techniques used depend on the soil type, the equipment available and the weed problem.

Farmers seeding at the break or just before the break need only create sufficient tilth to cover the seed. Control weeds the year before seeding and by grazing six weeks after seeding. Spray-graze if necessary. Seeding before the break ensures early germination and minimises herbicide costs, but increases the risk of weed problems and redlegged earth mite attack. In addition, false breaks can be a problem and, on light soils, there is a risk of wind erosion. After seeding, control weeds with herbicides, or by grazing.

Seeding after the break, into moist soil, requires waiting for a full germination and then killing weeds by cultural and/or chemical means, as well as by grazing after seeding.

Seedbed preparation

To seed conventionally the soil needs working to produce a seedbed. Use tined or disc implements to break up and bury the old pasture. On the next rain work it back to produce a fine seed bed. Seed as soon as moisture conditions are suitable. Broadcast or drill the seed and fertiliser. Sow subterranean clover and ryegrass 10 to 15 mm deep. Sow species with smaller seed (e.g. balansa clover) 5 to 10 mm deep.

Drills, whether spring tine combines or single disc drills, accurately place seed and fertiliser into worked soil. Rolling after seeding breaks up clods, compacts the seedbed and improves seed-soil contact.

Perennial grasses need total weed control with herbicides before seeding and need sowing after the break. Perennial grasses require a particularly firm seed bed.

Advantages of cultivation

- Allows conventional disc drills and spring tine combines to achieve optimum seed and fertiliser placement.
- Reduces incidence of insect pests and some root diseases. Root diseases are a particular problem where the old pasture had a heavy thatch as is often the case in kikuyu and couch pastures.
- Increases the rate of release of nutrients from organic matter by mineralisation.
- Increases seedling vigour.
- Reduces surface soil compaction.
- Increases soil temperature by removal of plant residue which would otherwise reflect heat away from the soil.

Disadvantages of cultivation

- Delays seeding time while waiting for and killing several germinations.
- Each cultivation brings more weed seed into the surface layer of soil and stimulates another germination.
- Each cultivation reduces available soil moisture.
- The soil is left fragile and erosion prone.
- Soil organic matter is mineralised and prone to loss by wind or water erosion or leaching.
- Soil strength and crumb structure is weakened.
- Tractor time, fuel costs and overall machinery wear is increased.
- Plant residue cover is removed.
- The paddock is left prone to waterlogging making subsequent movement of machinery, vehicles and stock difficult.
Direct drilling

Direct drilling involves sowing the seed directly into unworked soil. Weeds are controlled in an integrated program using grazing and herbicides. Seed is sown using a machine capable of penetrating hard soil, covering the seed and giving good control of seed and fertiliser placement. Combines with narrow points having a leading edge only 6 to 10 mm wide, or a triple disc drill ensure that only the seeding band is worked leaving the inter row area unworked. This minimises weed germination.

Depth and tilth

Sowing depth is not as critical as the amount of worked soil covering the seed. With ‘T’ boot furrows aim for 20 to 30 mm deep furrows and the seed covered with 5 to 15 mm of loose soil in the furrow. Five to ten per cent of the seed may be visible in the furrow. This practice gives good seed/soil contact. In cold, wet conditions make the furrow shallower.

Do not use harrows or a roller behind the drill when direct drilling with inverted ‘T’ boot points. The furrow may fill in and bury the seed. Flood irrigating after seeding has the same effect.

Advantages of direct drilling

- Increases flexibility of paddock management. You are not committed to taking the paddock out of production until the final application of knock-down herbicide. You can also sow before the break.
- Better control of seeding depth. (Must have adequate soil penetration/tine tension to get into soils which may be dry or hard).
- Paddocks remain trafficable after seeding.
- Less pugging by stock.
- Reduced soil erosion risk.
- Requires less labour and less time.
- Allows early seeding with minimum delays for weed control.
- Better weed control.
- No stimulation of later germinations by the seeding cultivation.
- Negligible loss of soil moisture by cultivation.
- Target weeds can be removed selectively before seeding new varieties into the modified sward.

This coil tine seeder has a rigid frame and is fitted with Baker Boot points.
Disadvantages of direct drilling
- High capital cost of new machinery (cost can be reduced by modifying conventional drills).
- Reliance on herbicides for weed control requires good knowledge of their use and application.
- Greater insect activity may increase insecticide use.
- Reduced cultivation means less organic matter breakdown – so less nutrients, particularly nitrogen, are released from the organic matter and made available to the new pasture.
- Greater chance of root rot disease, which can cause substantial seedling loss.
- Direct drilling does not tackle soil compaction problems.

Conventional seeding or direct drill?
Many factors affect the choice between conventional methods of establishing pasture and direct drilling. These include your own experience, and your willingness to try new technology. We suggest you study the topic by seeing a local demonstration, reading about direct drilling and trying it out for yourself. Either way, try only a small area in the first year.

Then consider your machinery capacity; are you well set up for cultivation; do you have a drill or a combine?
A combine may be suitable for direct drilling if it can penetrate hard soils. Narrow points may be fitted (leading edge 6 to 10 mm wide), they only cultivate the seeding band and do not cut out weeds between the seeding rows.

Combines can be converted relatively cheaply to produce good direct drill seeders. Single disc drills do not cover the seed well when used for direct drilling. Is it practicable to modify your drill for direct seeding?

Do you have a boom sprayer and the skills to use it? Are contractors available for spraying or direct drilling?

Finally you need to decide which system is most appropriate for you.
Calibrating the seeder

The most accurate way to determine the quantity of seed and fertiliser going through the seeder is to measure it under paddock operating conditions. To do this:

- devise a system to catch the output of the machine (a bag or series of buckets to catch seed or fertiliser from all tubes);
- calculate the gear setting required from the manufacturers chart of gear ratios or from the cog ratios on the machine — if this is not possible, choose another setting and test again;
- set the machine to the approximate rate required (measure seed and fertiliser separately);
- operate the machine until all tubes are running, then fit the bags or buckets;
- run the machine for a known distance (e.g. 100 m) across the paddock to be sown, at normal sowing speed;
- weigh the total output from the machine.

To calculate the application rate, divide the output (in kilograms) by the area treated (distance run multiplied by width of machine).

Example:

A 20 run combine (width 3.6 m) puts out 3.75 kg of fertiliser over 100 m distance.

Area treated: 3.6 x 100 = 360 sq m
= 0.036 ha (1 ha = 10,000 sq m)
Application rate: 3.75 kg divided by 0.036 ha
= 104 kg/ha

To short-cut this system (but at reduced accuracy):

- measure output from fewer tubes — this increases errors because not all tubes run at the same rate;
- measure over shorter distance — this increases errors at start and finish of the run and magnifies errors in measuring weight of output;
- measure by turning wheel of the machine when jacked up in the shed. This method does not account for the effect of agitation in the box while moving over the paddock or for the effect of tyre inflation and load on rolling diameter.

If you decide to use this method determine the number of wheel rotations to travel about 100 m under paddock conditions at half load, then jack the machine up and measure the output for the predetermined number of wheel rotations.

Note that manufacturers calibration charts are often not accurate and that different batches of fertiliser and seed can run differently. Use last year’s settings as a guide only.

As you seed you should check the area covered for each seeder box full, but remember that area meters fitted to seeders may be inaccurate.

Calibrate air seeders using the same method. Try to catch the output before it enters the airstream.

Before starting seeding, check that the seeder is levelled front to rear and side to side. Also check that tine tension is sufficient to penetrate the soil and operate to a consistent sowing depth.

Tine tension for zero till will be considerably higher (180-200 lb, 780 N-860 N) than for sowing into cultivated soil (60-90 lb, 260 N-400 N).

Once in the paddock, check that the machine is sowing at the correct depth and watch that sowing depth stays within the acceptable range as the seeder empties and as it moves across differing soil types or from cultivated to uncultivated ground and back.
Points and discs

A wide range of points and discs are available for conventional and direct drill/zero till operations.

**Conventional**

Cultivation is usually done with a disc cultivator fitted with plain or scalloped discs to give better penetration through plant debris, or with a scarifier fitted with 15-20 cm points. Seeding can then be done with a disc seeder, culti trash or combine with 10 cm points or by broadcasting.

**Direct drill**

Direct drilling is a one pass seeding operation, usually done with a rigid tine seeder with sufficient tine pressure (breakout) to allow good penetration into unworked ground. Usually points are at least 10 cm wide to ensure full cut out of weeds (at standard 18 cm row spacing). In this system, the seeding operation kills weeds and acts as a ‘double knock’ following a knockdown herbicide.

**Minimum or zero-till**

A one pass seeding operation done with a triple disc drill or a rigid tine combine fitted with narrow points (leading edge 6 to 10 mm wide). The range of narrow points include lucerne points, inverted ‘T’ points (Baker Boots and Caldow points) and knife points.

Some moderately narrow chisel points (25 mm wide) can peel a strip of sod out of the furrow leaving the seed exposed at the bottom of the furrow.

Zero tillage leaves the soil almost undisturbed and so does not stimulate germination of weed seeds or kill weeds. Undisturbed soil is also better able to resist erosion. In abrasive soils, points need to be made of cast iron, but this can make the point more brittle; so take care to choose the point material (cast or steel) and the hard facing treatment that suits your soils.

*Standard combine points ensure that a full cut of weed is taken. They suit direct drilling operations, but cause more soil disturbance than narrow points or triple disc drills.*
Maintenance and calibration of spraying equipment

The importance of having the boom sprayer accurately set up and calibrated cannot be overstressed. Huge losses can be incurred through incorrect herbicide application. Losses range from total failure of the herbicide to kill the weeds, to the extreme where an overdose of herbicides kills both weeds and pasture, and may even leave residues in the soil.

Maintenance of spraying equipment

A sound knowledge of the care needed to prepare and effectively operate sprayers has become essential. Farmers are placing increasing reliance on costly herbicides and the boom sprayer has become standard equipment on many farms.

Accurate application of herbicide ensures maximum benefit and the best return from investment in chemicals. Farmers in Western Australia now spend some $100 million a year on herbicides, so accurate application represents considerable savings to the whole industry.

Even if overdosing does not cause pasture damage, the extra cost of the unnecessary herbicide can be significant. For example, a 10 per cent overdose with an expensive herbicide ($40/ha), means a loss of $400 for every 100 hectares sprayed (Figure 1).

Effective maintenance is the first requirement for boom sprayer accuracy. Start maintenance at the end of each year’s spraying.

Maintenance at the end of the spraying season

- Remove and clean all nozzles and filters.
- Flush water through the sprayer to remove any chemicals or deposits, especially if you have used flowable or powder formulations. Fitting manually controlled taps or solenoid valves to the ends of the boom sprayer arms simplifies flushing and allows any deposits between the last nozzle and the end of the boom to be removed easily.

Decontamination

Unused chemical left in the tank, boom or hose lines can cause major damage to pastures if it contaminates the next herbicide treatment, especially if they are not suitable for that particular species, or applied at the incorrect growth stage. It is very important that all traces of the chemical are removed before another herbicide is used.

- 2,4-D, MCPA or dicamba – Ester forms of these chemicals provide the greatest risk of contamination, particularly high concentration formulations. If you have used ester formulations, soak the spray unit with clean water for 24 hours to leach chemical out of hoses and gaskets.

Wash out the spray unit with 1 per cent ammonia solution (1 L household ammonia per 100 L water) or with washing soda (2 kg per 100 L water). Rinse the spray unit thoroughly with water. Regrease the pump after decontamination.

![Figure 1. The cost of applying too much herbicide to an area of 100 ha.](image-url)
- Sulfonylurea herbicides, chlorsulfuron, Logran® and metsulfuron methyl – These chemicals can cause severe damage to legumes at very low concentrations, particularly when activated by some of the grass herbicides.

Strip filters, and soak screens and cartridges overnight in 1 per cent chlorine. Wash out the system with 1 per cent chlorine (100 mL of 4 per cent solution to 100 L water). Drain out and repeat but leave the solution in the unit overnight. Rinse thoroughly with clean water. Regrease pump.

- Read the label carefully before decontaminating spray equipment; failure to follow the clean-up procedure closely may lead to pasture damage after your next spraying.

**Maintenance before starting to spray in the current season**

- Refit the clean filters and nozzles and run a small amount of clean, filtered water through the system.
- Check all hoses and connections and replace any faulty parts.
- Check nozzles for wear. This is the most important, yet most neglected maintenance requirement. Set the pump pressure at the manufacturer’s specification then measure (usually over a minute) the output from a few nozzles. If the flow rate is much higher than that suggested by the manufacturer, buy a new set of nozzles. Manufacturers usually supply charts of flow rates.
- If the nozzles tested appear satisfactory, measure the output of the remaining nozzles and record the volume. It is usually helpful to record the volumes in set order along the boom so that any faulty nozzles can be located. The easiest way to remember nozzle positions along the boom is to paint the numbers of each nozzle along the arms of the boom.
- The measurement of the output is critical, so it is important to use accurate measuring devices. A clear plastic or glass measuring cylinder marked in 2 or 5 mL graduations is ideal (Figure 2). Large diameter jugs or thick coloured plastic vessels give inaccurate readings. Use cylinders with 2 mL graduations to measure low volumes. These are available from medical, scientific instrument and some agricultural suppliers.
- While checking the nozzles, observe the pattern produced by each nozzle. A good nozzle produces a very even fan. The volumes of the spray deposits are at a maximum directly below the nozzle and taper away evenly in both directions from the centre. A badly blocked or worn nozzle can produce an uneven fan. Look into the spray fan to judge the pattern of the spray from a nozzle. Any unevenness of output will show up as a distortion in the fan.

All nozzles in the boom should be of the same brand; nozzles of similar 'size' produced by different manufacturers tend to vary in output and spray pattern.

**Nozzle maintenance in the spraying season**

Checking the nozzle output regularly during the spraying season is essential, because:

- filters become blocked;
- nozzles wear, particularly if you are using powdered or flowable formulations; and
- pressures may have changed.

A quick method is to use one of the several monitoring devices now available from agricultural suppliers. However, these devices should not be relied on for accurate calibration, particularly with low volume applications. They should only be used as a guide to how the nozzles are performing.

Another check is to select several nozzles and compare their outputs with those recorded in the earlier calibration.

After an even set of nozzles has been fitted, calibrate the sprayer. There are many methods for calibrating, usually involving a series of mathematical steps.
Calibration of motorised/P.T.O. (constant speed) boom sprayers

A simplified method designed for boom sprayers with nozzles at 50 cm spacings is summarised below.

1. Measure the output of each nozzle for one minute. This should already have been done when choosing an even set of nozzles.

2. Measure the combined output of all nozzles and divide by the number of nozzles. This gives average output per nozzle in millilitres per minute (mL/min).

3. Decide on a speed of travel for spraying.

4. Measure out a distance of 100 m and record the time taken to cover the distance with the spray unit. It is important to calculate the speed on a surface similar to that being sprayed. Figure 3 shows the time taken to cover the 100 m at various speeds. You can calculate it by:

   \[ \text{Speed (km/h)} = \frac{360 \times \text{time (seconds)}}{100} \]

5. Refer to Figure 3 to obtain the output in litres per hectare (L/ha). Take a line across the figure from the average output of the nozzles you have measured to the speed you have selected. Trace a vertical line from where these two meet to the edge of the figure to find the output (L/ha).

   Alternatively, calculate the output using the following formula:

   \[ \text{Output L/ha} = \frac{\text{Average output of nozzle (mL/min)} \times 60}{\text{Nozzle spacing (cm)} \times \text{spraying speed (km/h)}} \]

A quick check for boom sprayers with 50 cm nozzle spacing is:

\[ \frac{\text{Average output per nozzle (mL/min)}}{\text{speed (km/h)}} \times 1.2 \]

Other calibration formulae and methods are given in Bulletin 4216, ‘Broadscale boom spraying’.

Calculation of how much herbicide is needed

To calculate the amount of herbicide needed for each tank of spray, the tank size (volume) must be known. Dividing the tank size by the output (L/ha) gives the number of hectares that can be sprayed with each tank.

Then multiply the rate of herbicide required per hectare by the number of hectares that can be sprayed per tank to get the amount of herbicide added to each tank.

For example, for a tank of 1000 L capacity, and a sprayer calibrated to deliver 50 L/ha, the number of hectares that can be sprayed per tank is calculated as follows:

\[ \frac{\text{Tank size (L)}}{\text{Sprayer output (L/ha)}} = \frac{1000}{50} = 20 \text{ ha} \]

If the rate of herbicide to be applied is 2 L/ha, then the amount of herbicide added to each tank is 2 L/ha x 20 ha = 40 L.

Ground-driven boom sprayer calibration

Like all farm equipment, ground-driven boom sprayers require regular maintenance. They also require calibration.

The main difference between these and the motorised/P.T.O. sprayers is that they have their pump coupled directly to the wheel. Therefore changing the ground speed changes the pump output so that a uniform application is made per unit area regardless of speed.

Checks, maintenance and calibration

1. Check tyre pressures. Tyres must be kept at the right pressure to ensure the correct number of wheel revolutions per hectare (for computer sprays 18 p.s.i. or 124 kPa).

2. Check the agitator jet in the bottom of the spray tank regularly for blockages, excessive wear or corrosion. Fit a trickle irrigation filter in the agitator line to reduce the chance of blockage.

Blockage causes an increase in the volume of spray applied by the nozzles and prevents agitation during spraying. If the jet is enlarged, the output of the boom decreases. Fit a liquid-filled pressure gauge (0-600 kPa) to the agitator line. Maintain a pressure of between 200 and 350 kPa while working using standard nozzles. Any pressure rise indicates the agitator jet, tip filter or nozzle is blocked.

For computer sprays, standard wire gauge drill bits may be used to clear blockages in the agitator jet, but check the correct size for your model with the manufacturer. A small sliver of wood, such as a toothpick, could also be used.
3. The pump should be maintained regularly. Fluid discharging from the cover plate on the rear of the pump is a sign of severe wear. A low reading on the pressure gauge also indicates a worn pump.

4. Supply water to the boom under pressure from a fire fighting pump or the water mains and check the nozzles in operation. Replace any which differ from the average output by more than 5 per cent or show streaks in the fan pattern.

5. Disconnect the main line to the boom and fix it to collect liquid into a container (e.g. a 10 to 20 L bucket). Record the flow over a measured run (at least 400 metres). Drive around in a circle in the paddock before starting the run to ensure that all lines are full.

A flowmeter also could be used to measure the output.

6. Now calculate the sprayer output using this formula:

\[
\text{Spray output (litres/ha) =} \frac{\text{Output (L)}}{\text{Area (ha)}}
\]

Example

Swath width = 12.2 metres
Length of run = 400 metres
Output of all nozzles during run = 23 litres

Area covered = 12.2 x 400 = 4880 m² = 0.48 ha

Output in litres/ha = 23 litres = approx. 48.0 L/ha
0.48 ha

The amount of chemical to add to the tank is calculated in the same manner as for the motorised/P.T.O. boom sprayers.

7. One final check – the speed. Keep between 8 and 15 km/h. At higher speeds too many fine droplets are produced. If the speed is excessive the pressure gauge will show a high reading. Small droplets may drift off target, wasting chemical and perhaps damaging susceptible crops. Keep the spraying pressure at 200 to 300 kPa. Speed may be calculated using the method already described.

**Marking systems**

A good marking system is essential to prevent overlap or missed areas when spraying. Overlap of the spray swath results in areas being sprayed twice, which wastes both herbicides and time. The possibility of developing herbicide resistance in weeds is also increased because of the greater selection pressure in those areas that receive a double dose.

Missed areas can result in uncontrolled weeds, reduced pasture yield, provide weed seeds for next year’s pasture or contaminate hay or harvested seed.

Details of systems available are given in Bulletin 4216 ‘Broadscale boom spraying’ and Farmnote 14/93 ‘Foam markers for use on boom sprays’.

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*Figure 3. Calibration of a boom with 50 cm nozzle spacings*
Diseases of annual pasture legumes

Fungal and viral diseases continue to limit the productivity of annual pasture legumes. They seriously diminish both the amount of herbage produced, its nutritional quality, the amount and viability of seed produced and, through their effects on root nodulation, the amount of nitrogen fixed in the pasture. Decreased seed production results in pasture deterioration which necessitates more frequent reseeding. Annual pasture legumes seriously damaged by fungal and viral diseases include subterranean, balansa, Persian and arrowleaf clovers, and annual medics. Diseased pastures result in heavy production losses, estimated at over $100 million annually in Western Australia. In high rainfall areas the most serious fungal diseases are clover scorch and root rot. The most serious viral diseases are subterranean clover mottle virus (SCMV) and bean yellow mosaic virus (BYMV).

Causal agents

The clover scorch fungus, Kabatiella caulivora, seriously damages susceptible subterranean clover varieties in high rainfall areas. Phytophthora clandestina, Pythium irregulare, Rhizoctonia solani and, to a lesser extent, Aphanomyces eutiches, Fusarium avenaceum and other Pythium spp. are fungi which all have an important role as causal agents of damping-off and root diseases on annual clovers in high rainfall areas. Investigations clearly indicate that different individuals or complexes of root pathogens operate between seasons at any one location, and between locations, for any one season.

SCMV infection is very widespread in subterranean clover pastures in the south-west. Spread occurs mainly in late winter and spring and the virus is transmitted from plant to plant by grazing animals (especially cattle and sheep). BYMV is also widespread in pastures in the same area, again sometimes reaching very high incidence in spring. The bluegreen aphid is the main vector and greatest spread of the virus occurs in pastures in bad aphid years. Arrowleaf clover is particularly susceptible to BYMV. Subterranean clover cultivars differ in susceptibility to both viruses. Levels of viral disease in pastures vary according to variety, grazing pressure and, for BYMV, aphid occurrence.

Control using management or chemicals

Stock will not graze a pasture collapsed from clover scorch but one way of coping with affected pastures is to graze them heavily throughout the season. Grazing removes much of the affected material and, if continued, may enable new growth to be used before it becomes infected. As susceptible cultivars are replaced, clover scorch control with fungicides will become less important. However, fungicides are still a profitable short-term control measure in clover-dominant hay crops and seed crops of susceptible varieties. Spraying fungicides such as Benlate®, Bavistin® and Spin® has produced profitable increases in hay yields.

Root rot is often less severe on recently cultivated land but the effect rarely persists long-term. In some situations cultivation can reduce stand density, cause a loss in production and increase root knot eelworm damage.

Attempts to control root rot in subterranean clover in Western Australia using fungicides have been generally unsuccessful.

For SCMV, high stocking rates increase spread, especially in spring. Seriously affected pastures should be closed up and used for hay, silage or dry feed. Where levels of infection are less, stocking should be reduced to allow the pasture to grow up over 20 cm. This decreases virus spread by shading out the more stunted, infected plants and reduces the source available for further spread.

For BYMV, heavy grazing in spring is also not recommended, since this favours survival of infected plants which act as sources for further spread by aphids. Reduce stocking to allow infected pastures to grow up so that neighbouring healthy plants shade out infected clover plants. If possible, close up the affected pastures for hay or silage. If small virus-infected patches or isolated plants are noted in late winter, consider applying an aphicide (e.g. a pyrethroid) to kill aphid vectors and thereby delay further spread. However, do not use aphicide sprays on tall, dense swards as the spray is unlikely to penetrate adequately.
Control using disease resistant cultivars

Since 1972 the Department of Agriculture has screened subterranean clover cultivars and crossbreds for reaction to clover scorch and root rot.

Clover breeding has successfully incorporated a number of sources of resistance to clover scorch and has produced the cultivars listed below. Cultivars with improved resistance to damping-off and root rot have also been identified.

Subterranean clover cultivars resistant to fungal diseases

- **Denmark** – a late maturing cultivar with good resistance to clover scorch and root rots.
- **Gosse** - an early mid-season cultivar with good resistance to clover scorch, cercospora disease and phytophthora root rot.
- **Goulburn** – a late mid-season cultivar with good resistance to clover scorch, root rots and leaf rust.
- **Junei** – an early mid-season cultivar, has good clover scorch resistance and root rot tolerance.
- **Karridale** – was selected for its high level of resistance to clover scorch but recent experience has shown that it can be severely affected occasionally, particularly in ungrazed seed production stands. It has good tolerance to root rot.
- **Larisa** – although not selected for clover scorch resistance, it does have a useful level of resistance to scorch. It has good resistance to phytophthora root rot.
- **Meteora** - has excellent resistance to clover scorch and to phytophthora root rot.
- **Trikkala** – also not selected for clover scorch resistance, but it does have a useful level of resistance. It has good resistance to phytophthora root rot.

Since 1990, the major subterranean clover cultivars have also been screened for resistance to SCMV and BYMV.

Subterranean clover cultivars resistant to viral diseases

- **Larisa** and **Trikkala** have excellent resistance to SCMV but are susceptible to BYMV.
- **Meteora** has excellent resistance to SCMV but is highly susceptible to BYMV.
- **Goulburn and Denmark** have reasonable resistance to SCMV but are susceptible to BYMV.
- **Gosse** has excellent resistance to SCMV, but is susceptible to BYMV.
- **Leura** has reasonable resistance to SCMV but is highly susceptible to BYMV.

The high rainfall cultivars most susceptible to BYMV include Denmark, Karridale, Meteora and Leura, while for SCMV they include Dinninup, Junee and Woogenellup.

Good resistance to BYMV has only been found in the shorter growing season cultivars Dalkeith, Dwalganup, Nungarin and Rosedale.

Further reading


BMYV infection in Woogenellup leaves showing vein clearing (centre) and vein clearing and mottle (right). Healthy leaf on the left.

SCMV infection in Woogenellup leaves showing mottle, leaf deformation and reduced leaf size. Healthy leaf on the left.

Patch of dwarfed and mottled BYMV-infected plants in a Karridale sward.

Close up of sheep track showing dwarfed plants with SCMV symptoms surrounded by healthy plants.

Intervenial pallor (chlorosis), mottle and leaf deformation in BMYV-infected plants of variety Karridale.

Screening for resistance to SCMV – left row, Denmark (partially resistant); right row, Woogenellup (susceptible). Only Woogenellup shows widespread SCMV symptoms of yellowing and dwarfing.

Patch of dwarfed and mottled SCMV-infected plants in a Woogenellup sward.
Pasture pests

Redlegged earth mite and blue oat mite

Redlegged earth mite (Halotydeus destructor) and blue oat mite (Pentaleus major) may reduce legume herbage and seed yields by up to 80 per cent. They are most damaging at pasture emergence and in spring if seed reserves are low. Control at these times is worthwhile if damage (silvering) is obvious. However, pest numbers and damage are very dependent on the grazing pressure.

Heavy grazing during winter and spring controls these pests as well as chemicals do (see later).

Redlegged earth mite (RLEM) populations often include 10 per cent or more of another pest; the blue oat mite (BOM) which attacks grasses to a greater extent than RLEM. The body of both pests is nearly black and the legs are red-orange. The BOM has a bluish tinge and has its anus in the middle of a red patch on its back; a good magnifying glass or microscope is needed to see this. BOM is harder to kill than RLEM and requires higher rates of insecticide than those registered for RLEM.

Lucerne flea

Lucerne flea (Sminthurus viridis) is favoured by clay or loam soils and is rare on sands. When in large numbers it may be as damaging as RLEM, but it eats the green plant material instead of sucking it.

The lucerne flea (LF) is a plump, wingless insect, 2 to 4 mm long. Colour varies but the larger specimens are predominantly green and yellow. They usually spring from plant surfaces when approached. Grazing pressure, moisture and a predator are the major factors affecting numbers.

Aphids

Pasture aphids do not have any males but reproduce extremely rapidly under the right conditions by giving birth to live young. Winged aphids fly into pasture from green host plants and produce aphids without wings which colonise the pastures, particularly those which are legume dominant.

Bluegreen aphid may be active in spring and in warm autumns after early breaks, especially in irrigated pastures. The most severe damage usually occurs in spring.
## Life cycle of redlegged earth mite

<table>
<thead>
<tr>
<th>Season</th>
<th>Weather</th>
<th>Wet/dry</th>
<th>Generation</th>
<th>Pest activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td>Cool. Daytime below 21°C</td>
<td>Wet</td>
<td>1st</td>
<td>Drought-proof eggs hatch within a week. Produce six legged larval mites. Several moulttings occur. Mites get bigger, develop eight legs.</td>
</tr>
<tr>
<td>Winter</td>
<td>Cool-cold</td>
<td>Wet</td>
<td>2nd</td>
<td>Mites feed and lay winter eggs. Winter eggs hatch within 7-14 days of laying. Some winter eggs laid and hatch immediately. As temperatures rise and pastures mature, mites produce drought proof eggs.</td>
</tr>
<tr>
<td>Spring</td>
<td>Cold-warm</td>
<td>Wet</td>
<td>3rd, 4th*</td>
<td></td>
</tr>
<tr>
<td>Late spring to summer</td>
<td>Warm-hot</td>
<td>Dry</td>
<td></td>
<td>Drought-proof eggs in body of dead female in dust on soil.</td>
</tr>
</tbody>
</table>

* In long growing seasons there may be four generations, otherwise three.

## Life cycle of lucerne flea

<table>
<thead>
<tr>
<th>Season</th>
<th>Wet/dry</th>
<th>Generation</th>
<th>Pest activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td>Wet</td>
<td>1st</td>
<td>Soaking rains wet through clay capsules and trigger eggs hatching. Pest feeds and lays eggs.</td>
</tr>
<tr>
<td>Winter</td>
<td>Wet</td>
<td>2nd</td>
<td>Eggs hatch, flea feeds and lays eggs.</td>
</tr>
<tr>
<td>Spring</td>
<td>Wet</td>
<td>3rd*</td>
<td>Eggs hatch, flea feeds and lays eggs.</td>
</tr>
<tr>
<td>Late spring</td>
<td>Dry*</td>
<td></td>
<td>Eggs remain dormant within clay capsules, which are thick and survive summer.</td>
</tr>
<tr>
<td>Summer</td>
<td>Dry*</td>
<td></td>
<td>Eggs in heavy duty summer capsules.</td>
</tr>
</tbody>
</table>

* If conditions remain wet as in irrigated areas, lucerne flea may be active throughout the year.

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Pastures germinating in February or March and growing through warm autumn months may also be attacked by spotted clover aphid, which is almost identical to spotted alfalfa aphid which attacks lucerne and medic.

**RLEM, BOM and LF damage**

Two or more pests may be present and cause damage at the same time although one will usually dominate.

RLEM and BOM suck sap from cotyledons and leaves, resulting in a silvery or distortion of the plants. LF eats green surface tissue, producing clear windows or holes in the leaves. Plant growth rate and yield may be reduced.

**Autumn**

Heavy infestations at seedling emergence may kill plants or severely retard growth, especially of the legumes. If RLEM and BOM emerge after seedlings are established, plant death is unlikely and growth rates are less affected.

**Winter**

When plant growth is slow due to cold, waterlogging or a dry spell, pest attack can reduce plant growth even more.

**Spring**

Large pest populations in spring, especially during flowering, can result in reduced total dry matter production of up to 30 per cent. Legume herbage and seed yield may be reduced by up to 80 per cent.

**Aphid damage**

**Autumn**

Spotted alfalfa aphid can kill more than 80 per cent of plants. The damage is difficult to detect until it is severe and plants begin to die. Aphids suck sap from stems and underneath leaves. The sward begins to yellow, then brown off and die.

**Spring**

Bluegreen aphid feeds in a similar way to spotted clover aphid. Leaves turn a grey-brown and become crisp and dry. White speckling, which may be seen under the top leaf canopy, is due to the skins discarded by aphids as the grow.

**Control – grazing management**

Tall, dense pastures encourage pasture pests. Grazing reduces pest numbers in actively growing pastures in winter and spring. How much, depends on how heavily pastures are grazed. If pastures are grazed hard enough to consume herbage as fast as it is growing, and maintain the available feed at about 1.5 t dry matter/ha, pest control may be better than achieved with chemicals. Grazing to maintain feed between 1.5 t and 3.0 t dry matter/ha will reduce pests to below damaging populations. ‘Crash grazing’, where pasture is eaten down to less than 2.0 t dry matter/ha in a short period reduces pests to low numbers, but the period for which pests remain low depends on subsequent grazing practice.

But if pasture growth rates are low and heavy stocking is not practical, then grazing alone may not control pests sufficiently to prevent pasture losses. Indeed, at the break of season when plants are germinating and pest activity is high, grazing is less effective in controlling pests. Deferring grazing in autumn encourages mites. However, autumn pest populations will be very low if they were controlled in the previous spring by grazing or insecticides. This strategy works by preventing the carryover of drought proof eggs from spring through summer.

**Biological control**

A lucerne flea predator (the pasture snout mite) is present in most areas occupied by the pest. This predator often reduces lucerne flea below economic control levels but predator numbers are affected by dry seasons, cultivation and grazing. Its numbers are not greatly reduced by the chemicals commonly used against mites and fleas. More effective predators of lucerne flea, the spiny snout mite, and the French anystis mite — a predator of mites and fleas — were introduced to Western Australia but as yet have a very limited distribution and they have no means of rapid dispersal.

Biological control of aphids is usually ineffective in preventing population outbreaks. High numbers of ladybird beetles, parasitic wasps and other beneficial insects are usually found when pest numbers are high.

**Chemical control**

Insecticides are effective against the active stages of these pests but have no effect on eggs, so control of the entire population is not possible with one treatment of a short-lived chemical as the eggs may hatch over several weeks.

Two sprays applied one to two weeks apart should give extended control of RLEM and BOM, possibly for the whole season, by killing young mites as they hatch from ‘summer eggs’. It need not be expensive as relatively cheap chemicals can be used.
The decision to use a chemical will be based on the susceptibility of the pasture and the presence of damaging pest populations. Planting of legumes into old pasture demands treatment.

Damage may be observed even before the pests are noticed. Treatment should not be delayed if damage to seedlings is severe. Maturing pasture should be treated if the extra feed produced is likely to be used effectively, or a greater seed production is required because the legume content is low or the paddock is to be reseeded.

Where bare ground or seed treatments are contemplated, the emergence of these pests can be anticipated if the required weather conditions (a week of cool, wet weather) have prevailed. In high risk situations, where pastures are reseeded, adopt a preventative approach.

**Sprays**

The systemic insecticides, dimethoate and omethoate, are effective at the rates given if applied to plant material, but not to bare ground. Contact insecticides may be used on bare ground but are more effective when sprayed on growing plants. They also act systemically. The contact/systemic pesticides are: azinphos-ethyl, chlorpyrifos, demeton-s-methyl, maldison, methidathion.

Endosulfan and increased rates of methidathion are specifically registered for use against redlegged earth mite on bare ground before seedling emergence. Although this method is expensive, the advantages are that the young, vulnerable seedlings are protected and the problem of spraying later, when the land may be boggy, is avoided.

See Bulletin 4286 ‘Chemical control of insect pests in field crops and pastures’ for registered products for controlling insect pests in pasture.

**Seed treatment**

Dimethoate or omethoate may be used as a seed treatment to provide seedling protection against attack by these two pests. Rates of product in Bulletin 4286 should be diluted in the amount of water suggested and added to 100 kg of seed.

The seed and chemical should be mixed as follows.

1. Place seed in a cement mixer.
2. With the cement mixer operating, mix one of the insecticides with half the specified volume of water and add this mixture to the seed.
3. Add sufficient of the remaining water to ensure that all the seed is moistened.
4. Run the mixer for a further 30 to 60 seconds so that there is no excess moisture.
5. Bag the seed and store overnight.

**Safety:** This operation should be carried out in an area with good ventilation and the appropriate protective clothing and equipment should be worn. This includes overalls, gloves, mask and goggles for dimethoate or a hood which covers the head for omethoate.

Treated seed should be sown as soon as possible, as delay will reduce the treatment effectiveness. Dry seeding will have the same effect.

These insecticides will kill the bacteria if applied to inoculated seed. However, Le-mat® is registered for use on seed 24 hours before inoculation.
Grazing systems and pasture management

Grazing resown pastures
Give newly seeded pastures a quick grazing about six weeks after seeding or when the ryegrass has produced its third leaf. This early grazing encourages tillering, controls broad-leaved weeds and encourages clover growth. Sheep cause less pugging than cattle so graze off the pasture with sheep if possible. However, prolonged intense grazing with sheep at this time will reduce grass content.

After grazing down to 4 to 5 cm high, remove the stock and allow the pasture to recover before grazing again. Keep the pasture grazed down between 5 and 8 cm tall until mid to late spring then remove all stock to encourage clover and ryegrass seed production.

Encourage seed production by:
- spraying to control insect pests in early spring;
- grazing the pasture;
- not cutting for hay or silage;
- if conserving cut high and cut early.

Newly seeded pastures growing in waterlogged soils need special care. Pugging damages both pasture and soil so graze these pastures with young stock. Attend to drainage problems before seeding the pasture.

Grazing established pastures
Pasture management involves the manipulation of pastures, animals and supplementary feed to maximise farm profit year in year out.

The key to maximising farm profit lies in efficient pasture utilisation, high stocking rates and producing high levels of animal product per hectare.

But pasture growth rates and pasture quality vary throughout the year. Dry land pastures have zero growth in summer, low growth in most autumn/winters and rapid growth in spring. Irrigated pastures suffer from waterlogging in winter which reduces growth and accessibility, a flush of growth in spring and declining growth and quality during summer. Pasture growth rates also vary with soil type and land capability.

Therefore pasture management presents farmers with a considerable challenge. A variety of grazing systems exist on south-west farms as farmers meet this challenge in different ways. But which grazing system maximises farm profits? Should farmers have a continuous grazing system, set stock, or graze rotationally – and if rotationally what system of rotational grazing?

To answer these questions we need to understand how the pasture plant grows and what happens when we graze it and vary:
- the duration of grazing;
- the intensity of grazing;
- the interval between grazings.

We also need to study the different grazing systems and see how they affect pasture growth and pasture utilisation and farm profit. An introduction to the principles concerned and their practical application follow. Further treatment of the topic will be dealt with in other publications and/or later editions of this publication.

Plant growth
Pasture plant growth can be illustrated by using ryegrass as an example.

Ryegrass provides a good visual gauge of when to graze a pasture even when clover dominates the sward. Ryegrass is a multi-tillered plant. Each tiller has its own root system. Tillers die and new tillers are produced throughout the growing season.

The tiller
At the centre of each tiller is the shoot. During the vegetative phase the shoot lies near the soil surface. So you can graze ryegrass short and it will still regrow.

Each tiller produces three leaves in succession. As the fourth leaf emerges the oldest leaf begins to die (Figure 1). In the reproductive phase, ryegrass produces up to six leaves before any die.

Leaf appearance rate depends on the weather and the nutritional status of the plant but not on grazing intensity or on nitrogen. In warm weather new leaves appear every five to seven days. In winter, they appear every 10 to 15 days, perhaps longer in the coldest weather. If a new leaf appears every 10 days it will take 30 days for the complete three leaf cycle. Each new leaf lives for 30 days and then dies – unless it is grazed beforehand.
Note: Nitrogenous fertiliser increases tillering and leaf size but not leaf appearance rate.

Tiller regrowth after grazing depends on the plant reserves and the amount of leaf residue left after grazing.

**Plant reserves and the growth cycle**

Reserves (carbohydrates) stored in the roots and stubble fuel regrowth after grazing. The reserves move from the roots and stubble into the newly developing leaves (Diagram 1 in Figure 2). Root growth stops for three to six days.

As the second and third leaf develop, the photosynthetic capacity of the plant increases, increasing carbohydrate production in the leaves. The carbohydrates move down to the roots and stubble, thus replenishing root and stubble reserves (Diagram 3 in Figure 2).

In this way pasture plants recover from grazing. If grazed at the one leaf stage when the plant reserves are depleted the plants will not ‘bounce back’. Grazing at one leaf stage also reduces root growth and increases pasture damage.

**Leaf residue and shading**

Stock eat the youngest leaves and leave the oldest leaves behind. These old leaves are rarely photosynthetically active. If too many leaves remain, they shade the new leaves and tillers developing lower in the canopy restricting regrowth. This problem occurs in lightly grazed pastures, grazed to 12 cm or higher.

Pasture grown and not used is pasture wasted.

When grazed down to 5 to 7 cm very little shading occurs and regrowth is rapid, provided stock do not graze the plant before it produces the second and third leaf.

**Which grazing system?**

So which grazing system will return the farmer the most profit? Set stocking, rotational grazing or controlled rotational grazing? The Department of Agriculture has started investigating grazing systems and pasture utilisation on dairy, beef and sheep farms. Controlled rotational grazing looks promising for dairy farms but the work on beef farms is at a very early stage so no conclusions can be made yet. On sheep farms rotational grazing and continuous grazing systems are under study.

**Set stocking and continuous grazing**

Set stocking is a low labour input system used mainly by beef and sheep farmers. Livestock are allocated an area to graze which meets their feed requirements throughout the year with minimal feed supplementation. Sometimes paddocks are spelled for hay and silage production or to allow a grazed out pasture to recover. In set stocked systems livestock graze individual plants or tillers at intervals.

The frequency of grazing each tiller depends on stocking rate and pasture growth rate.

Set stocked pastures often have more tillers than rotationally grazed pastures, but the tillers in the set stocked pasture are smaller than those in the rotationally grazed pasture.

Pasture production and animal production from the two systems may be the same. It depends on how well stocking rate is balanced with pasture production. Set stocking is most commonly out of balance with pasture production in autumn (slow pasture growth) and spring (fast pasture growth). Set stocked pastures are often overgrazed in autumn/winter and undergrazed in spring.

**Set stocking and continuous grazing**

To successfully achieve high stocking rates with set stocking you need to make a good match between animal demand and feed supply (as in late
winter lambing) and have good reserves of cash, grain or conserved fodder. As in controlled rotational grazing described below you need a flexible management system that allows changes to stocking rate, the feeding of supplements and high levels of fodder conservation with progressive closing of silage and hay paddocks. In effect this converts a set stocking system to a continuous grazing system but at a higher though flexible stocking rate.

Department of Agriculture investigations on the management of pastures continuously grazed by sheep suggest upper and lower feed boundaries needed to maintain pasture production and hence animal production at a high level. The farmer needs to adjust hand feeding levels, stocking rate and the fodder conservation program to keep the pasture within these boundaries (see Table1, over page).

**Rotational grazing**

In rotational grazing systems the livestock are moved around at regular intervals – perhaps one week grazing and three weeks rest. Alternatively, because paddock sizes and paddock productivity vary, the livestock may be put in when the paddock is 'ready' for grazing and taken out when the paddock is 'finished'. The grazing period may be a few days, a week or two or longer.

Moderate fodder conservation levels make autumn deferment difficult in a late break and the pasture may be overgrazed in autumn/early winter and undergrazed in spring.
Table 1. Suggested feed on offer (FOO) boundary values (kg green DM/ha) for three growth periods for optimum production by annual pastures

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Establishment ‘Autumn’</th>
<th>Vegetative ‘Winter’</th>
<th>Flower/seed set ‘Spring’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower boundary (kg DM/ha)</td>
<td>800</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>Upper boundary (kg DM/ha)</td>
<td>2500</td>
<td></td>
<td>3500</td>
</tr>
</tbody>
</table>

**Controlled rotational**

Controlled rotational grazing (CRG) is based on grazing pastures when the ryegrass reaches the 3 to 3½ leaf stage. Each area is grazed for one to three days to allow rapid recovery after grazing. Because pastures grow more slowly in winter, intervals between grazings in winter are long.

Winter grazing intervals range between every 30 days (new ryegrass leaf appearing every 10 days) and 45 days (new leaf every 15 days).

Short grazing intervals, about 15 days, prevail in spring. As the pasture grows away from the stock in early spring some paddocks are progressively closed up for hay or silage. High levels of fodder conservation is a key component of CRG.

Controlled rotational grazing needs paddocks, or grazing areas, no more than three days grazing in size. So CRG requires smaller paddocks than normally occur on our farms.

Electric fences facilitate this more intensive subdivision, make back-up fences possible and give the fencing system flexibility. With electric fences, paddocks can be made smaller in winter, larger in spring and increased as the herd grows.

Dairy cows can graze pastures down to 6 to 7 cm high without affecting the milk production of individual cows. While beef cows can graze pastures down to 3 cm high for short periods without affecting the final weaning weight of the calf.

For most of the growing season maintain maximum calf growth rates by grazing beef pastures no shorter than 5 cm.

**Starting the autumn rotation with CRG**

Until it rains in autumn, there is no green pasture. Then it rains and all the pastures start growing at once. When should CRG start?

Department of Agriculture trials showed that cutting new ryegrass seedlings at the two leaf stage did not slow down early or total ryegrass growth, provided the plants were allowed to regrow to the three leaf stage before being harvested again. On the farm this indicates that grazing can start when ryegrass reaches the two leaf stage. Graze each paddock in succession, moving the herd around the farm so that the first paddock has reached the three leaf stage when it has its second grazing.

The rotation speed you need depends on ryegrass leaf appearance rate. As a guide, initially assume a seven day leaf appearance rate and, hence, a 21 day grazing cycle. Give the herd a grazing allowance of ⅓ of the pasture per day. Check the pasture ahead of the cows every week so you can determine the actual leaf appearance rate. Adjust the rotation rate accordingly. Speed it up if the pasture is growing faster than one new leaf per seven days. Slow it down if it is growing slower.

Keep supplementary feeding levels up high until you have built up a bank of feed. Big plants grow faster.

**Other factors affecting choice of grazing system?**

The type of grazing system for your farm will vary according to your property’s pasture types, topography, type of stock, paddock size, farm size, and your attitude.

Topography limits paddock size. Steep slopes are difficult to manage and erosion prone if fenced into small paddocks. Flat country may be prone to waterlogging and subject to pugging when grazed heavily.

Large farms may have limited labour resources and so use low labour grazing systems such as set stocking. Some loss in pasture growth and quality may be more profitable than employing the labour needed for controlled rotational grazing.

Controlled rotational grazing takes some extra time and needs extra fencing and water points. Will the increase in pasture production, often achieved by controlled rotational grazing, be profitable on beef, sheep and dairy farms? The Department of Agriculture’s studies, now in progress, should help you assess the situation.
Renovating irrigated pasture

Many irrigated pastures are dominated by kikuyu. This grass provides valuable feed during summer – especially when kept short and in a mix with ryegrass and white clover. But on many paddocks kikuyu has become rank, smothering out the ryegrass and clover. Kikuyu, especially rank kikuyu, is much less nutritious than ryegrass and clover. Irrigated kikuyu may carry a lot of stock during summer but milk production per cow is low (10 L/cow) – as are sheep and cattle growth rates – unless the stock are fed grain supplements.

Chemical manipulation

Control kikuyu by spraying with glyphosate. Start the program in autumn or spring. The autumn start program has three phases. Sow down to Concord ryegrass in March/April, a summer fodder crop in November/December and finally a short rotation ryegrass, perennial ryegrass, white clover mix in the second autumn. This program, which gives you three opportunities to control kikuyu with glyphosate, has worked well at Wokalup Research Station and on commercial dairy farms.

If the paddock is well drained, well fertilised and grazed in a rotation with other paddocks you will achieve good medium term control of kikuyu and grow a highly productive pasture. Kikuyu will not dominate again for another five to six years (Wokalup Research Station experience). The profitability of this program is assessed in the chapter on ‘Economics of pasture improvement’. It broke even in the second year and is highly profitable.

Operational detail

First prepare the kikuyu by heavy grazing, foraging or slashing and rolling to remove as much kikuyu top growth as possible.

- Allow the kikuyu to recover for 10 days. Then spray the leafy stand of kikuyu with glyphosate (450 g/L) at 2.5 to 3.0 L in 100 L water per hectare. Leave for two or three weeks before burning or mulching and seeding.
- Oversow by direct drilling – triple disc or narrow tine drill.
- Alternatively, lightly cultivate the soil, broadcast the seed and use harrow to cover.
- Because the glyphosate translocates slowly through the plant to the root system the kikuyu should be undisturbed for two, and preferably three, weeks after spraying.

Seed mix

<table>
<thead>
<tr>
<th>Seed mix</th>
<th>Concord at 20 kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>First autumn:</td>
<td>Embassy perennial ryegrass 7 kg/ha</td>
</tr>
<tr>
<td>Second autumn:</td>
<td>Ellett perennial ryegrass 7 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Concord 7 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Haifa white clover 2 kg/ha</td>
</tr>
<tr>
<td></td>
<td>Kopu white clover 2 kg/ha</td>
</tr>
</tbody>
</table>

Useful annual clovers for sowing in the first autumn include:

- Shaftal – good autumn and hay production;
- Balansa – waterlogging and salt tolerance, good spring production;
- Meteora – subterranean clover for annual pastures irrigated in spring;
- Include Palestine strawberry clover in perennial pastures where salinity is a problem;
- Paspalum has a place because it grows fast in summer and tolerates salinity better than ryegrass.

General management

Take full advantage of the productive potential of the new pasture with good land and pasture management. Graze the pasture each time the ryegrass reaches the 3½ leaf stage. Kikuyu and paspalum grow faster than ryegrass and clover in summer. So, when kikuyu and paspalum reinvade the pasture, graze summer pastures more frequently to control the kikuyu and paspalum.

Soil test before you start unless you plan to laser level the paddock first.

Make sure the surface drainage system works well during summer and winter (tail drains, spinner cuts and a good fall to the Water Authority outlet).

If direct drilling, sow with a mixed fertiliser containing nitrogen.

Rip the soil before sowing a fodder crop and pasture in spring and/or late summer as needed (see next article).

Compacted soils need ripping before sowing the summer fodder crop and before sowing the perennial pasture mix.
Irrigated pasture management

General
Successful management of irrigated pastures requires skills in fertiliser management, grazing management, irrigation, drainage, animal management and farm planning. This article covers key features of some of these important skills.

Fertiliser practice
Irrigation farmers need to ensure that their fertiliser program feeds their irrigated pastures well, but at acceptable cost and with minimal nutrient loss to the drainage system. Soil testing and timing provide the keys to meeting both these needs.

Timing
Apply most phosphatic and potassic fertilisers in early spring. Clover and grass both start their main growth period in early spring and low soil phosphorus or potassium levels at this time will severely reduce spring and summer pasture production.

To keep nutrient losses to a minimum apply the fertiliser three weeks before the first irrigation or just after irrigating. Better still apply fertiliser before irrigating but ensure there is no loss of water into the tail drain.

Irrigation farmers with loam or clay soils have little need of sulphur. So DAP (17.5 per cent nitrogen, 20 per cent phosphorus) and triple superphosphate (20 per cent phosphorus, 1 per cent sulphur) are practical alternatives to superphosphate for irrigation farmers. DAP (S355/t bulk at works) is a cost effective source of nitrogen and phosphorus in combination.

December/January is a good time to apply nitrogenous fertiliser. Use urea – it is cheaper per unit of nitrogen than sulphate of ammonia or ammonium nitrate.

Soil testing
Establish soil test monitoring strips in key paddocks. A diagonal strip from near the bottom of a bay to the top is appropriate. Avoid the salty, waterlogged bit at the bottom (if any). Soil test in autumn or early spring. Keep records of fertiliser applied and soil test results.

Irrigation practice
Soil type effect
Loamy soils have good moisture holding capacity. Therefore pasture growing on loamy soils holds up better between irrigations than on poorer soil types.

Heavy clays (Bungham Clays) often have a poor soil structure. So water infiltration rates are low and moisture holding capacity is poor. Irrigated pastures have more trouble maintaining growth rates between irrigation on these soils than on well structured loams. The problem is most severe in recently laser levelled paddocks. Saving the top soil when laser levelling, and replacing it on top of the laser levelled land helps the soil return quickly to a productive, well structured state.

Drainage, organic matter (cow manure) and good pasture management improve soil structure and moisture water holding capacity. It can take time. Timely ripping improves rooting depth and soil structure if drainage is adequate. Rip when good growing conditions for clover and ryegrass prevail, particularly in autumn and just before seeding.

Species, irrigation frequency
When the soil moisture content drops to the wilting point, plant growth stops. Therefore irrigate before the pasture starts to wilt. Pasture plants vary in their tolerance of moisture stress.

Researchers at Kyabram Research Station in northern Victoria have discovered that:
- white clover needs irrigating after 50 mm evaporation;
- perennial ryegrass needs irrigating after 70 mm evaporation;
- paspalum needs irrigating after 100 mm evaporation.

So the Victorian Department of Agriculture advises farmers to irrigate at 50 mm evaporation. Our advice is to irrigate at 70 mm evaporation, but you should decide on the best practice for your farm. Remember, when wilting starts plant growth has stopped. Evaporation figures are broadcast by the media. Ripping and drainage encourage deeper rooting allowing the plant to explore a greater volume of soil for water and nutrients. Salinity increases moisture stress.

Water quickly, minimise losses
The soil in the pasture root zone absorbs 90 per cent of the water it can absorb in the first hour. So water quickly. Have wide, clean, head ditches and wide bay outlets so each bay waters quickly. Have the head ditch/bay outlet system designed to make full use of the flow from your Detheridge Wheel.
When convenient install automation. Also minimise losses to the tail drain. The Wellesley and Dardanup LCDCs both have moulds for 1 m wide bay outlets available for loan to farmers.

**Drainage**

Waterlogging and salinity are two major problems affecting pasture production in the irrigation areas. Much of the irrigation area is underlain by shallow (0.5 to 1.5 m deep), saline water-tables. This drives the salinity problem that affects part of many farms in the irrigation area. Waterlogging reduces plant growth and reduces the farmer’s ability to graze stock on irrigated pastures in winter and early spring.

When stock do graze these wet waterlogged pastures they pug the soil, destroying its structure and reducing pasture productivity and quality in spring and summer. The Dardanup and Wellesley LCDCs have targeted drainage as a problem that needs investigation and solving.

Good surface drainage systems will probably solve, or substantially reduce, the problem on many farms. The surface drainage system needs to be effective winter and summer. Ponding irrigation water for 24 hours at each irrigation reduces white clover productivity by 25 per cent.

Start planning the drainage system at the Water Authority outlet so the tail drains all flow smoothly to the outlet. Farmer experience indicates that a minimum bay slope of 0.25 per cent is needed and maximum bay length of 200 to 300 m. Spinner cuts and well maintained tail drains at least 500 mm deep complete the picture. V-shaped tail drains are more stable than straight sided drains.

**Sub-surface drainage – mole drainage**

Internationally, mole drainage is considered as the most cost effective system of draining pastures. Many irrigation farmers have tried a form of mole drainage.

More recently NLP finance has enabled the Department of Agriculture to start investigating mole drain/collector pipe systems on four farms in the irrigation areas and at Wokalup Research Station. The project is being tackled in consultation with the two LCDCs. A visit by Professor Gordon Spoor of Silsoe UK (June 1993) has brought more skills on the topic to Western Australia. Current on-farm trials on mole draining should determine its profitability.

**Grazing management**

The need to utilise pasture efficiently and to match pasture supply and supplementation with animal needs apply just as much to irrigated pasture farming as it does to dryland pasture farming.

Irrigation farmers have two spring growth flushes to deal with. One on dryland pastures and one on irrigated pastures. Irrigation farmers are usually advised to concentrate their pasture management efforts on their irrigated pastures so as to keep them vegetative well into summer. Paspalum

*Mole drainage with a modern mole plough. This mole plough was built with NLP funds for use in the south-west irrigation areas.*
quickly becomes rank and of low feed value if not kept leafy by grazing, topping, mulching or conservation. But concentrating the management effort on the irrigated pastures often allows the annual pastures to become rank and grassy. A resource gone to waste! Use fodder conservation, hay freezing and grazing to utilise both spring flushes.

Perennial ryegrass and white clover persist better in competition with paspalum and kikuyu when pasture management suits ryegrass and white clover.

Therefore, ensure that the drainage system is effective, that irrigation intervals are at 70 mm evaporation and the ryegrass is grazed each time it reaches the 3 to 3½ leaf stage (see main ‘Grazing management’ chapter). However, in mid-summer, paspalum and kikuyu grow faster than ryegrass and the pastures will need grazing before the ryegrass reaches the 3½ leaf stage to keep the kikuyu and paspalum under control.

White clover thrives under this regime too. Aim to minimise shading by ryegrass in winter and by paspalum and kikuyu in summer. Light encourages white clover stolons to produce daughter stolons.

The more stolons the more growing points. The more growing points the more leaves and hence more production.

Although white clover tolerates high temperatures (up to 35°C) fairly well, if well watered – in practice most irrigated pastures suffer a significant decline in white clover content over summer. Salinity puts additional pressure on white clover, as does competition from kikuyu and paspalum. So the grasses tend to dominate.

Manage kikuyu by grazing it hard or mulching it. Increase the stocking rate. Aim to leave a stubble of 5 cm (8 cm in hot weather), then allow the leaves to regrow. This system improves white clover persistence, white clover productivity and the productivity of the kikuyu/white clover pasture. Eventually the pasture will need renovating (see previous chapter).
Weed control in irrigation channels

Introduction
Channel weed control is essential to achieve maximum water flows in tail drains and in head ditches. Weed free head ditches enable faster irrigation and more efficient use of water.

Mechanical methods – drain spinners and back hoes – give immediate results, but chemical methods give long-term weed control. Back hoes are proving valuable in deepening shallow tail drains but they may also lower the drain bed below culvert level and cause water ponding. This encourages aquatic weed growth.

Grazing gives temporary control only and if done during wet conditions damages the channel thus adding to weed and silt problems.

Herbicides play an important part in controlling channel weed growth and are part of many on-farm channel maintenance programs for both head ditches and tail drains.

Identify the weed then use the herbicide and the method that suits the situation. Read the directions on the label.

The table over page is partly based on the Rural Water Commission of Victoria’s recommendations for channel weed control.

Umbrella sedge (umbrella ‘grass’) is resistant to glyphosate but is effectively controlled by amitrole.

Mixtures of glyphosate and amitrole, or glyphosate and Pulse Penetrant®, may control umbrella sedge, and are currently being tested in the field.

Pulse Penetrant® – a Monsanto product – improves herbicide efficiency by ensuring thorough wetting of the leaf surfaces and promoting herbicide penetration of leaf tissue.

High volume application is generally more effective in channel weed control than controlled droplet application (CDA). Repeat spraying may be needed. In tall, dense stands of weeds, CDA applied herbicides do not penetrate the stand effectively.

For residual control use 880 mL simazine or 500 mL atrazine per 100 L of water or herbicide mix.

Apply to drain bank when channel/drain water levels are low and before the irrigation season starts.

If 50 to 100 mm of rain does not fall before irrigation starts, flush the channel with water before irrigating.

Herbicide trade names

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Trade name</th>
<th>Distributor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,2-DPA 850 g/L</td>
<td>Grapon Grass Killer®</td>
<td>David Grey</td>
</tr>
<tr>
<td>2,2-DPA 750 g/L</td>
<td>Pro-Pon®</td>
<td>Nu Farm</td>
</tr>
<tr>
<td>Amitrole 250 g/L</td>
<td>Amitrole T®</td>
<td>Nu Farm</td>
</tr>
<tr>
<td>Amitrole + Ammonium thiocyanate (320 g/L)</td>
<td>TL Plus®</td>
<td>Ciba Geigy</td>
</tr>
<tr>
<td></td>
<td>Weedazol TL Plus®</td>
<td>Rhone-Poulenc</td>
</tr>
<tr>
<td>Glyphosate 360 g/L and 450 g/L</td>
<td>Many products registered</td>
<td></td>
</tr>
<tr>
<td>Weed species</td>
<td>Herbicide</td>
<td>Rate/ha</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>---------</td>
</tr>
<tr>
<td><em>Cumbungi Typha sp.</em></td>
<td>2,2-DPA or Glyphosate (360)</td>
<td>20-40 kg 9 L.</td>
</tr>
<tr>
<td><em>Rushes Juncus sp.</em></td>
<td>Glyphosate (360) + ammonium sulphate 2 kg/100 L of mix</td>
<td>9 L + 100 mL</td>
</tr>
<tr>
<td><em>Celery buttercup (Ranunculus)</em></td>
<td>Amitrole + ammonium thiocyanate</td>
<td>25 L.</td>
</tr>
<tr>
<td><em>Duck weed Lemna minor</em></td>
<td>Glyphosate (360) or Reglone®</td>
<td>9 L (note 1) 5 L</td>
</tr>
<tr>
<td><em>Paspalum (Paspalum distichum)</em></td>
<td>Glyphosate (360)</td>
<td>6 L (note 2)</td>
</tr>
<tr>
<td><em>Water couch (Paspalum distichum)</em></td>
<td>Glyphosate (360) or Amitrole + ammonium thiocyanate</td>
<td>9 L 25 L.</td>
</tr>
<tr>
<td><em>Umbrella sedge</em></td>
<td>Amitrole + ammonium thiocyanate</td>
<td>25 L</td>
</tr>
</tbody>
</table>

*L = litre  mL = millilitre  m = metre*
## Low volume application - controlled droplet application

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Herbicide</th>
<th>Nozzle (Micron Herbi)</th>
<th>Mixing herbicide:water</th>
<th>Walking pace (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paspalum</td>
<td>Glyphosate</td>
<td>Small (blue)</td>
<td>1:1</td>
<td>1</td>
</tr>
<tr>
<td>Rushes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water couch grass</td>
<td>Glyphosate</td>
<td>Medium (yellow)</td>
<td>2:1</td>
<td>1</td>
</tr>
<tr>
<td>Celery buttercup</td>
<td>Amitrole</td>
<td>Large (red)</td>
<td>No dilution (note 3)</td>
<td>0.5</td>
</tr>
<tr>
<td>Water couch grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Umbrella sedge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Before treatment starts, the water level should be lowered as much as possible to expose all the leaves. The spray should be applied lightly and droplets should be allowed to settle on the floating leaves without forcing the leaves under the surface.

Note 2: Apply spray lightly; do not saturate the plants.

Note 3: Add 1 per cent surfactant (10 mL/L).
Barley grass (*Hordeum leporinum*)

**The problem**

Stock readily eat barley grass during the vegetative stages, but barley grass seeds have long sharp awns. So when the seed heads develop, stock graze other pasture species in preference to barley grass.

**Autumn/winter control – pasture manipulation**

Control barley grass in legume pastures using grass selective herbicides; Targa® Verdict®, Fusilade® or Select®. Apply the chemicals early in the season, late May to early June, when barley grass is at the two to five leaf stage. Delay application if germination is uneven or incomplete. These herbicides cause no damage to subterranean clover, annual medics or lucerne. Use full label rates (cost $15 to $20/ha).

These grass selective herbicides also control annual ryegrass and may damage or kill young perennial grasses.

For lower cost control in subterranean clover pastures use a simazine/paraquat mixture. Rates depend on soil type. Heavy soils tie up simazine and reduce its activity. Generally 500 mL of simazine and 500 mL of paraquat/ha is effective. Apply after the clover has reached the six leaf stage. The treatment suppresses clover growth for two to three weeks after application and early treatment enables clover to recover during a period of warmer weather and better growing conditions.

Graze carefully following the simazine/paraquat application. Three to four days after spraying introduce stock, graze closely for several days (this aids control) then graze more laxly to allow clover recovery.

Check sprayed pastures regularly to make sure that clover is not overgrazed.

**Lucerne**

2,2 DPA controls barley grass in lucerne and medics. Apply at 2-3 kg/ha when the barley grass has two to four leaves. 2,2 DPA causes severe damage to subterranean clover.

Paraquat controls barley grass and other annual grasses in established lucerne. Apply it in autumn/early winter.

**Seed set control**

Barley grass flowers over a long period and so is a difficult target for spring seed set control. One application of paraquat gives partial control. Two applications three weeks apart give good control but may reduce clover seed set. Glyphosate controls seed set more effectively than paraquat but damages pasture legumes more, than paraquat.

Graze after pasture topping to reduce the number of seed heads that escape spraying, especially if the seed heads remain green.

Mechanical topping is another option. Repeated mowing may be necessary to control grass regrowth.

Barley grass is difficult to remove from perennial grass stands. Most registered herbicides (*Kerb® and Carbetamex*) are too expensive for application to large areas. 2,2-DPA, damages perennial grasses and clover. Paraquat is registered for use in cocksfoot, perennial ryegrass, phalaris and Demeter fescue, but stands must be at least 12 months old. Leaf burning is likely to occur.

**Barley grass seed heads (heads/m²) present in September 1992 following either spray topping in 1991 or pasture manipulation in 1992**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Seed heads/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sept 1992</td>
</tr>
<tr>
<td>Nil</td>
<td>340</td>
</tr>
<tr>
<td>Paraquat 500</td>
<td>Spring 1991</td>
</tr>
<tr>
<td>Simazine 750</td>
<td>Autumn 1992</td>
</tr>
<tr>
<td>+</td>
<td>Nil</td>
</tr>
<tr>
<td>Paraquat 750</td>
<td></td>
</tr>
</tbody>
</table>
Bracken fern (Pteridium esculentum var aquilimum)

The problem

Bracken fern is a perennial plant with an extensive underground root system. In dense stands it excludes all pasture species. The thick leathery fronds shade out plants underneath. When they die, they fall creating a mulch to stop annual species germinating. Soil toxins are also released which retard the growth of perennial species and surviving annuals.

Bracken patches spread about 1 m a year in ungrazed areas. The roots send up new fronds each spring which thrive in the areas cleared of competition by the dead fronds. In grazed areas, the spread is limited by stock trampling.

The palatability and feed value of bracken is low. This is fortunate because if stock do eat it they can be poisoned. Cattle and horses are most sensitive to bracken poisoning followed by sheep. Goats are rarely affected.

Chemical control

Control by spraying with Brush-off® or Trounce®.

Bracken can be controlled by boom spraying 40-60 g/ha of Brush-off® (metsulfuron-methyl). Best results are obtained if it is applied when the fronds have fully unfurled in early summer, are actively growing and when it rains a week or two after spraying. The higher rate is preferred on old stands where there is a large amount of root material in the ground. The addition of Pulse Penetrant® at 1 L per 400 L of spray mix helps provide better kills of the root mass and should be used on old stands or where the amount of fronds is small compared to the root system.

Brush-off® can be slow acting and the full effects may not be seen until the following season.

There is no need to slash bracken before using Brush-off®. In fact better results have been obtained on unslashed stands despite the presence of many old leathery and dead fronds. Where the bracken is too tall for the boom spray to operate effectively it can be slashed and the re-growth sprayed when it has grown about 300 mm high and most of the fronds have fully unfurled.

Spraying bracken that has been affected by a heat wave or frost is a waste of time – wait until next season.

It is very important to kill the few plants remaining in the next season by spot spraying with 10 g Brush-off® plus 250 mL Pulse Penetrant® in 100 L of water. These plants will soon re-infest the area if they are not controlled. If they are controlled, then the patch will be eradicated and will not return. This is because the bracken seeds or spores have very special germination requirements which normally only occur in old fire heaps.

Brush-off® will kill many other broad-leaved species and legumes such as clover, but does not affect perennial grasses.

Old fronds should be burnt and the area cultivated to reduce the soil toxins before new pasture species are planted.

Where perennial clovers are present below the bracken, a wick applicator may be used, but it is not as effective as boom spraying.

A solution of 1 L of glyphosate (450 g/L) plus 10 mL of Pulse Penetrant® in 3 L of water or 10 g Brush-off® plus 10 mL Pulse Penetrant® in 3 L of water can be used. The bracken should be wiped twice in opposite directions.

Glyphosate provides reasonable control of bracken at rates around 8 L/ha but is much more expensive and less selective than Brush-off®.

There is also a new product called Trounce® (which is a mixture of glyphosate and metsulfuron). Apply one of the 175 g sachets to 100 L water plus 100 mL Pulse Penetrant® and spot spray. Alternatively, use 7 to 10 sachets/ha plus 0.25 per cent Pulse Penetrant® for boom spraying. Roundup® and Trounce® will kill perennial grasses and other plants growing with the bracken.

Mechanical control

Repeated slashing or mowing will reduce bracken infestations but rarely eradicates them. Regrowth needs to be cut before it turns dark green and starts to build up the root system. Eventually the root system becomes exhausted by the continual production of fronds and dies.

Cultivation that brings roots to the surface so they dry out also controls bracken, if repeated each time a fresh crop of fronds emerges. On many of the soils where bracken occurs, the degree of cultivation required leads to soil erosion problems.

Controlling bracken mechanically costs much more than controlling it with herbicides.

Further reading

Farmnote 126/84: 'Control of bracken using the wick applicator'. Agdex 643.
Doublegee (Emex australis)

The problem

Doublegee is one of the worst weeds in Western Australia. It provides some grazing, but it also reduces animal production. Doublegee competes with legume pasture species and the spiny seeds (achenes) injure stock.

The spiny achenes cause infected ulcers on the mouths of grazing animals and cause crippling foot infections which restrict the animals ability to search for food. Reduced food intake due to foot and mouth infections, reduces animal production.

Control

Grazing – Use the grazing animal as the main management tool to maintain pasture balance and prevent doublegee dominance. High stocking rates usually lead to dominance by clover. However, close cropping rotations and low stocking rates make this difficult to achieve.

Use sheep, cattle or goats to graze all stages of doublegee growth, from seedlings through to mature plants. Sheep prefer prostrate plants like doublegee; goats and cattle prefer to browse and will eat taller vegetation.

Stock have the following advantages.

• Grazing may be more environmentally acceptable.
• Grazing may be more applicable in inaccessible terrain, provided fencing is adequate to keep the animals where they are required.
• Grazing provides a continuous, and therefore more effective, pressure on doublegee when germination is staggered or delayed.
• Goats preferentially graze weeds and allow the more valuable clovers to increase.
• Grazing preference of goats complements that of sheep and cattle. Therefore adding goats to sheep or cattle paddocks causes little or no loss of production.

Spray-grazing – Spray-grazing is a technique for the control of doublegee and many other broad-leaved weeds in pasture which relies on a sub-lethal dose of herbicide (usually 2,4-D or MCPA amine) to induce plants to wilt. This increases their palatability so animals graze them in preference to clovers and grasses which are not affected by the herbicide (see chapter ‘The spray-graze technique’ page 51).

Spray-grazing may be repeated every year until the bank of dormant seeds is reduced to a low level, but in many cases only one treatment is needed to maintain a good balanced pasture.

Biological control – Several potential biological control agents have been released in Western Australia over the past 20 years. An ongoing research program exists to study potential new biological control agents. So far none have been sufficiently successful to replace other methods of doublegee control.

Chemical control – Chemical control of doublegee in pasture has proved difficult. Few suitable herbicides are available, especially those capable of killing successive germinations without damaging pasture legumes.

Tribunil is effective if the doublegee plants have no more than five leaves, they are healthy and actively growing. Its price is a disincentive.

Some control is provided with 2,4-DB, but it is most effective in the warmer northern regions of the agricultural area. Successful doublegee control depends on the plants having less than eight leaves at the time of spraying and the paddock remaining under reasonably heavy grazing after spraying.

Mixtures of low rates of diuron with 2,4-DB are effective, but can cause damage to clover.

With the exception of Medicamine® on medics none of these herbicides can be used safely on the polymorpha medics.

Jaguar®, has both knock-down and residual weed control properties. It may be used in sensitive areas, such as near vineyards and commercial tomato crops. To control doublegee in clover pastures use 400 mL/ha on doublegee with two true leaves and 5 cm in diameter.

Recent research has shown that 25 g/ha of Broadstrike® can effectively control doublegee in pasture.

Herbicides for doublegee control

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribunil</td>
<td>850 g</td>
</tr>
<tr>
<td>2,4-DB</td>
<td>1.5 L</td>
</tr>
<tr>
<td>Diuron + 2,4-DB</td>
<td>250 mL + 400 mL</td>
</tr>
<tr>
<td>Jaguar®</td>
<td>400 mL</td>
</tr>
<tr>
<td>Spinnaker® + diuron</td>
<td>150 mL + 300 mL</td>
</tr>
<tr>
<td>Medicamine®</td>
<td>2.5 L</td>
</tr>
</tbody>
</table>
**Fiddle dock** (*Rumex pulcher*)

**The problem**

Established docks are very difficult to control in pasture without severely affecting the legume component.

At low densities (less than 25 per cent cover) docks do not affect pasture production. High densities reduce production by more than 50 per cent. Docks contain oxalate which reduces their palatability but rarely affects animal health. The woody stalks and toothed seeds are minor contaminants of wool.

Docks produce foliage in winter and a woody seed stalk in spring with up to 40,000 seeds. The top growth dies in summer but the carrot like rootstock survives in the soil and quickly produces large leaves in autumn to shade out germinating annuals. Most dock seeds germinate in autumn but late germinations are common where the soil is bared. Seed germinates in animal droppings, especially cow pads.

Eradication is not possible because seed survives in the soil for over 20 years. However, dock can be kept at low levels by careful management and spray-grazing.

Cultivation, mowing and slashing are generally ineffective because the dock regrows from the rootstock.

**Control strategy**

To control dock in pastures, kill old man docks first. Then treat the seedlings each year to prevent re-infestation. Herbicides that kill old man dock also kill clover and other legumes.

So, to control dock you need to sacrifice a year of clover production or plant the paddock to a grass crop such as oats or ryegrass.

For a heavily dock infested clover based pasture paddock use the following strategy:

- Reduce dock seed set by heavy grazing in spring.
- Apply 1.2 L/ha of glyphosate (450 g/L) in autumn after weeds have germinated. Scarify 3-7 days later and plant oats for grain or hay a few days later.
- When the oats reach the five leaf stage apply 700 mL/ha of dicamba (200 g/L) plus 700 mL/ha 2,4-D amine (500 g/L). (Use Glean® if ryegrass control is also required.)
- Harvest oats as grain or hay. Don’t burn the stubble because dock needs light to germinate whereas clover and ryegrass do not.
- Sod seed extra pasture seed the following autumn, if necessary. Include perennial grasses in

*Dicamba at 1L/ha applied in June controlled docks in this Keysbrook oat crop.*

85
the mix if they will persist. Perennials keep dock at low levels.

Spray-graze, using 750 mL/ha of 2,4-D amine (500 g/L) in early winter after the clover has more than 12 leaves and graze heavily one week later to control dock seedlings. Repeat each year to prevent reinfestation from dormant seed.

**Control measures for particular situations**

**Established perennial grasses with no legumes.**

Dicamba (200 g/L) at 500 mL/ha plus 500 mL/ha 2,4-D amine (500 g/L) will control dock in established perennials. Applications from June through to mid September are most effective. The later applications will provide control of seedlings that germinate during winter.

Do not delay spraying too long. Once the dock has started to bolt the dicamba/2,4-D amine mix gives variable control.

For long-term control of dock and seedlings a mixture of 500 mL/ha of dicamba (200 g/L) plus 1.4 L/ha of Tordon 242® is useful. This mix will kill many other broad-leaved species, including legumes, for several months after application.

**Clover based pastures**

There are no herbicides that provide high levels of old man dock control without seriously affecting clover and other legumes. Seedling docks can be controlled with 2 L/ha of 2,4-DB or 1 L/ha of 2,4-D amine using the spray-graze technique. Apply the herbicide about six weeks after the season opens when the clover has 8 to 10 leaves. One week later the paddock is grazed (preferably with sheep) at three to four times the normal stocking rate for the area. This provides good control of seedling docks and from 20 to 60 per cent control of older docks. If this is repeated each year the dock infestation will fall to low levels.

In heavily infested dock paddocks, it may be worthwhile applying dicamba plus 2,4-D despite the severe effect on the clover in the year of spraying. Table 1 shows the results of trials at Albany and Witchcliffe. It took four years for dock to return to its old levels after control with dicamba. Clover returned strongly in the year after spraying. Spray-grazing with 2,4-D amine could delay the dock reinfestation rate because most of the dock would be seedlings in the year after dicamba application.
Spraying late in the season around July/August is preferred. Early spraying tends to leave gaps in the pasture which dock seedlings quickly colonise. In one case, April spraying with dicamba led to 30 per cent more dock in the following year. Similar experiences with glyphosate and failed crops is common.

**Table 1. Densities of dock and clover (plants/m²) at various times after controlling dock with dicamba**

<table>
<thead>
<tr>
<th>Years since spraying</th>
<th>Albany 700 mm</th>
<th>Witchcliffe 1200 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ave Rainfall</td>
<td>Ave Rainfall</td>
</tr>
<tr>
<td>Dock</td>
<td>Clover</td>
<td>Dock</td>
</tr>
<tr>
<td>0</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>135</td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td>101</td>
</tr>
<tr>
<td>Many</td>
<td>93</td>
<td>72</td>
</tr>
</tbody>
</table>

**Grassed areas**

A mixture of 500 mL/ha of dicamba (200 g/L) plus 1 L/ha of Tordon 242® applied in winter before the dock bolts will control the docks present and prevent new germinations for the rest of the season.

For spot spraying use 100 mL of dicamba plus 200 mL of Tordon 242® per 100 L of water and spray the plant and surrounds until the point of run-off.

**Meadow hay and silage**

The level of dock infestation in meadow hay can be significantly reduced by spraying the paddock with 500 mL/ha of 2,4-D amine (500 g/L) two to three weeks before hay or silage cutting. This prevents the dock bolting and distorts the leaves so many of them fall below the level of the mower. In trials, the total quantity of hay produced has been the same and its quality is slightly better. There is also less risk of spreading dock through seed in the hay.

**Other methods**

Very early spraying before the clover has germinated or very late spraying after the clover has set seed have generally been ineffective. Dicamba, glyphosate, Glean® and Renovate® work well from May to September.

Glyphosate and glyphosate plus Ally® or Renovate® are used by some farmers after silage or hay cutting or after heavy spring grazing. Control looks good at first but many rootstocks recover the following season. Levels of control from 0 to 50 per cent are common.

Similarly rope wick application of a number of herbicides including glyphosate, dicamba and Ally® have given disappointing results by the following season.

**Cultivation**

Cultivation does not usually provide high levels of control and it requires hot drying weather to kill the exposed rootstocks. Cultivation tends to reduce the vigour of dock growth without killing the rootstock.

**Biological control**

Several biological control agents have been tested for action on dock. The most successful is a clear wing moth (*Chamaesphecia doryliformis*) released in 1989. This moth has only one generation a year, so movement from the release sites has been slow. Three years after release around 12 per cent of the dock rootstocks have been infected by the moth larvae. To obtain a quick distribution of this moth throughout the State, farmers will probably need to introduce it to their own properties.

**Warning:** In districts where commercial vineyards or tomato crops are within 5 to 10 km, use only amine or low volatile ester formulations of these herbicides. The restrictions apply to all hormone herbicides, i.e. MCPA; MCPB; 2,4-D; 2,4-DB; dicamba; 2,4,5-T and picloram.

If using an amine formulation within 5 km radius of a vineyard or tomato crop obtain a permit from the nearest office of the Department of Agriculture. Low volume ester formulations cannot be used within 5 km. Be careful with pastures dominated by Paterson’s curse; variegated thistle or capeweed; spray-graze increases their palatability and may cause stock poisoning due to excessive intake of toxins.
**Guildford grass** *(Romulea longifolia)*

**The problem**

Guildford grass is difficult to control. It invades weak pastures growing on infertile, hard packed soils where subterranean clover has trouble burying seed. Weed grasses often dominate and potassium deficiency is common.

Identifying and overcoming these problems is essential for long-term control of Guildford grass. Soil testing, improving the fertiliser program, controlling pests and diseases and making sure that the pasture suits the soil type are essential components of the control program. Compacted soils need ripping.

**Control**

There are few selective herbicide options for control of Guildford grass in clover pastures.

For **early season control**, chlorsulfuron – Glean®, Seige® and metsulfuron methyl – Ally®, Renovate®, Brush-off®, are effective at 10-15 g/ha applied before flowering, but they will kill clovers. Chlorsulfuron also kills annual ryegrass.

Apply both herbicides with a wetting agent. If Guildford grass leaves carry fungus (which they often do) use Pulse Penetrant® at 0.2 per cent of total spray volume. If no fungus is found, use cheaper, non-ionic wetting agents.

**Blanket wiper trials** in 1994 with chlorsulfuron and metsulfuron gave very good control of Guildford grass. Use 5 to 6 L/ha of one of the following spray mixes; chlorsulfuron 1 g/L water, metsulfuron 1 g/L water or a mixture of 1 g metsulfuron and 1 L glyphosate.

The metsulfuron/glyphosate mix also controlled wild oats. Use high rates of wetting agent, i.e. 500 mL/100 L spray mix (0.5 per cent) or 250 mL Pulse Penetrant®/100 L spray mix.

Trials at Manjimup have demonstrated that Guildford grass infested pastures can be renovated by spraying in autumn (May) with glyphosate (450 g/L) at 1.5 L/ha and Pulse Penetrant® at 200 mL/100L of spray mix. The Guildford grass was 75 to 100 mm tall at spraying and an excellent control was obtained.

Reseeding with a sod seeder and improved fertiliser (extra potash) completed the task.

A neighbouring area was also fertilised with extra potash but not sprayed or oversown. Pasture growth improved and this combined with cattle grazing eliminated the Guildford grass over three years.

Sheep are ineffective in controlling Guildford grass because they graze selectively around the weed.

Guildford grass in unthrifty pasture untouched by cattle because the pasture is poor.
Use **glyphosate** after flowering, when the herbicide is translocated to the bulb with sugars from the leaves. Rates of 1 to 2 L/ha are needed to kill Guildford grass.

The glyphosate kills the pasture – hay freezes it – thus limiting production. Because Guildford grass flowering coincides with clover flowering this treatment also reduces clover seed set. Use Pulse Penetrant® where high rates of herbicide are needed. Alternatively use glyphosate at flowering at 400 to 500 mL/ha (spray topping) to interrupt Guildford grass seed set without killing the pasture.

Because Guildford grass reproduces from bulbs as well as seeds, seed set control can only thin the population out, possibly by 50 to 70 per cent. This method allows clover to set some seed.

Spinnaker® applied in September at 200 to 300 mL/ha ($20 to $30/ha) also gives good control.

**Pasture renovation** incorporating cultivation is the best strategy for control of Guildford grass. It addresses the problems of soil compaction, low pasture seed bank, possible low fertility and allows herbicide and cultivation control of weeds. Each cultivation reduces Guildford grass density by about 50 per cent.

The renovation program should begin in spring with either a seed set control using glyphosate or spray-to-kill using chlorosulfuron/metsulfuron methyl (which will reduce pasture carrying capacity).

The new pasture can then be sown in autumn, allowing the Guildford grass to germinate before cultivating to kill weeds and produce a seed bed.

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**Parramatta grass** (*Sporobolus africanus/indicus*)

**The problem**

Parramatta grass is a perennial plant that prefers swampy areas or higher rainfall areas. It is tough, persistent, relatively unpalatable and far less digestible than most pasture species. It competes strongly with paspalum/clover pastures. Where it dominates pasture it produces large quantities of seed.

**Control**

Non-selective control has been obtained using 2,2-DPA at 10 kg/ha.

In trials in eastern Australia, fluopropanate (Frenock®) at 2 L/ha gave good selective control in clover pastures. However, it has a four month withholding period for grazing most stock. Lactating cows should not graze Frenock® pasture at all.

Fusilade® at 1 L/ha gave good control of Parramatta grass in trials at Dardanup without harming the clover. However, it also reduced the proportion of paspalum and kikuyu in the sward.

When renovating irrigated pastures 1.5 to 3 L/ha of glyphosate (360 g/L) gives good control of Parramatta grass.

Germination tests on fresh seeds suggest that Parramatta grass requires high temperatures (20°C to 30°C) to promote seed germination, so a late autumn spraying with glyphosate and then reseeding to pasture may help suppress reinvasion of the weed for a time.

Farmer experience indicates that mulching in spring suppresses Parramatta grass.
**Pennyroyal** *(Mentha pulegium)*

**The problem**

Pennyroyal is an aromatic, purple flowered, summer growing, perennial herb. It favours wet and waterlogged areas. The seeds will germinate and the seedlings survive in water up to a metre deep. It grows in drier areas but rarely forms dense infestations. It spreads by creeping stems, creeping roots and root fragments and by producing prolific quantities of seed. Flowering occurs between November and March.

It has toxic components but they do not appear to harm stock under normal grazing conditions. It may taint milk and meat but the taint disappears with pasteurisation of milk and within 24 hours of slaughter for meat.

About 5 per cent of the agricultural land in Denmark and Manjimup is infested with pennyroyal and it is spreading rapidly. Its presence indicates that the pastures species present are poorly adapted to the infested site or have serious growth problems. Pennyroyal occurs in many countries but is only a weed of significance in the south-west corner of Western Australia.

**Control**

Control pennyroyal with herbicides and by draining the land and by sowing pasture types suited to the site.

Begin pennyroyal control the season before reseeding pasture. Apply 20 g/ha of Glean® in spring to infested areas. Spray early to reduce the seed set of other weeds, or spray late to allow pasture species to set seed. Spraying will not kill perennial grasses but does damage perennial clovers.

In the following season, use glyphosate for broad spectrum weed control before planting. Use Spray.Seed® where control of perennial species is not desired.

Spray graze pastures with 1 L/ha of 2,4-D amine (500 g/L) each year in early winter. After two to four years the infestation will be controlled with minimal damage to the pasture. Buried seed remains viable in the soil for many years, so infested paddocks will need occasional follow up treatments after the main infestation has been controlled.

Chlorsulfuron (Glean®, Seige®) and metsulfuron methyl (Ally®, Brush-off®, Renovate®) are the best herbicides we have for pennyroyal control. They provide the best control when applied in autumn to spring. They both kill legumes. Summer applications after the clover has set seed provides reasonable control providing the pennyroyal is not stressed.

Slashing, cultivation and grazing are generally ineffective.

Spot spray small isolated infestations with a mixture of 1 g chlorsulfuron or metsulfuron methyl in 10 L of water.

A new herbicide, Spinnaker®, gave good control in trials. It reduces the grass and broad-leaved components in the sward but has little effect on clovers and legumes. It has given similar control to 2,4-D amine when applied in early summer.

**Further reading**

**Rushes (Juncus species)**

**The problem**

Rushes restrict the area of pasture available for grazing and interfere with water flow in irrigated pastures. They also interfere with hay making machinery. Because of their upright growth, rushes always appear to occupy more area than they actually do. However, if they are spreading, control at an early stage is more economical than waiting until they occupy large areas of pasture. Stock graze rushes lightly and obtain little feed value from them other than roughage. Rushes are expensive and time consuming to control.

**Control**

In areas that are inundated with water in winter, some control may be achieved by mowing (not slashing) close to the ground in autumn. This allows water into the stems and crowns which subsequently rot.

Many species can be pushed out with a tractor and blade in spring or summer once they have established a solid crown.

The most effective method is spot spraying with a mixture of 1 L of glyphosate (450 g/L) in 100 L water with 2 kg of crystalline ammonium sulphate (fertiliser type). First, burn or slash the rushes in autumn. Then spray them until just wet when the regrowth is about 300 mm tall in spring or early summer.

In dense infestations with valuable perennial pasture species, wick application can be used. A solution of 1 L of glyphosate (450 g/L) plus 2 L of water is used.

Wipe the rushes in one direction and then wipe again in the opposite direction. A single wipe often leaves the leeward side of large tussocks still alive but it is effective on smaller rushes.

Grazing and encouraging vigorous pasture growth will reduce reinfestation.

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**Slender thistles (Carduus species)**

**The problem**

Slender thistles can form dense stands that eliminate other pasture species or reduce pasture utilisation. Stock refuse to graze close to their spiny leaves and stems. They contaminate wool, making it unpleasant to handle. In a Boyup Brook survey, farmers believed they were losing $10 to $30/ha in thistle infested paddocks. Thistles have little value as a feed species. For each 1 kg of thistle that is produced, pasture production declines by 3 kg.

**Control**

Control thistles by grazing management and herbicides. Denser infestations occur in years with 'false breaks' and in paddocks that have been heavily grazed in autumn and early winter. The observation that thistles are more prevalent in paddocks grazed by sheep than those grazed by cattle generally reflects the different grazing patterns of sheep and cattle.

To control thistles by grazing, remove the stock when the thistles germinate in autumn and allow the pasture to grow 100 mm tall. This forces the thistles into a soft upright form instead of the usual low prickly rosette. The paddock is then heavily stocked. The combination of stress caused by grazing and competition by surrounding pasture plants usually provides adequate control.

Where deferred grazing cannot be used, spray-grazing with 2,4-D amine gives good control at little cost. Spray the pasture with 500 mL/ha of 2,4-D amine (500 g/L) when the clover has more than eight leaves and the thistle is in the rosette stage and 3-8 cm wide. One week later, graze the area heavily at three to five times the normal stocking rate.

Where heavy grazing is not possible the rate of 2,4-D amine should be increased to 1 L/ha. Wetting agents should not be used because they reduce the selectivity and may cause damage to the clovers. In midwinter, 2,4-D amine is less effective when the thistle rosette goes into a semi-dormant state.

Best results are achieved with early spraying or application when the first thistles are just showing signs of producing a stem. Once the thistles have bolted 2,4-D amine is usually ineffective. Slashing plants that have bolted is a better alternative.

Timing is critical. If slashed too early, or there are late rains, the thistles will reshoot from the base and will need to be slashed again. If slashed after the flower heads have opened some seed will ripen on the juices left in the stem. Slashing is better
than mowing because it damages the stems more and reduces seed maturing in the cut off plants.

Paraquat applied at 1 L/ha just before flowering gives good control of seed set.

**Rope wick applicators** using a solution of 1 L of glyphosate (450 g/L) in 4 L of water provides good control of the thistles contacted. However, the varying heights of the thistles often makes it difficult to achieve high levels of control.

For light infestations grubbing is effective and can prevent infestations establishing. In Boyup Brook, over half of the farmers actively controlling thistles use this method.

## Biological control

Spores of thistle rust (*Puccinia cardui-pycnocephali*) were released at several sites in south-west Western Australia during 1994. Thistle rust attacks both slender and sheep thistle.

The Western Australian release program coordinated by Jon Dodd (Department of Agriculture – 09 368 3679) is part of a National program coordinated by CSIRO, Canberra. Western Australian release sites extend south from the metropolitan area to Albany-Denmark.

## Sorrel (*Rumex acetosella*)

### The problem

Sorrel has arrow shaped leaves, rhizomatous roots, patchy distribution in the field and brown seed heads that emerge in spring and grow to about 300 mm tall.

Sorrel grows in unproductive established pastures and is a serious weed of crops and newly planted pastures. Causes of low pasture productivity resulting in sorrel invasion include: disease, pests, nutrient deficiencies or toxicities, extreme acidity, poor water holding capacity of the soil, poorly adapted varieties or, denudation caused by erosion, overgrazing, cultivation, repeated hay cutting or clover harvesting.

### Control

All the herbicides that provide high levels of sorrel control severely affect legumes. Therefore the most important step in a sorrel control program is to identify and correct the causes of poor pasture growth.

#### Moderate infestations

Spraying with glyphosate and Goal® (see chapter on ‘Effective weed control’) in autumn and then reseeding the pasture often controls moderate infestations of sorrel if pasture productivity problems are identified and tackled.

Alternatively, crop with oats or an annual or short rotation ryegrass the year before reseeding. Control the sorrel in-crop with 700 mL/ha dicamba plus 700 mL/ha 2,4-D amine.

Renovate® at 5 mg/ha applied post-emergence to oat crops also controls sorrel, but it may suppress ryegrass and reduce oat yields.

Reseed the pasture the year following cropping, making sure all the pasture production problems have been tackled. Use the glyphosphate and Goal® strategy of weed control before reseeding.

#### Severe infestations

For heavily infested areas crop the paddock with barley.

a) Apply 1 L/ha of glyphosate (450 g/L) plus 10 g/ha Renovate® in autumn. Scarify three to seven days later (and work the paddock in such a way as to reduce transfer of roots from infested to clean areas). Wait for a rain and at least 10 days, then plant barley.

b) Inspect the crop at the five leaf stage or later to determine if any root fragments have survived or new seedlings have emerged. Apply 5 g/ha Renovate® if necessary.

c) Sod seed extra pasture seed or perennials the following autumn if required. Include perennial grasses in the mix, if they will persist.

d) Spray-graze using 750 mL/ha of 2,4-D amine (500 g/L) in early winter if necessary.

Once the plants arising from rhizome roots have been killed, sorrel rarely reinfests healthy pastures to any extent.

### Sorrel patches

Patches of sorrel in pasture should be treated with 10 g/ha of Renovate®. This will kill legumes, but has little effect on grasses, so the area is not left bare. Legumes usually regenerate the next season.
Variegated thistle (*Silybum marianum*)

**The problem**

Variegated thistle is an important weed in pastures that is easily killed in the rosette stage, but much harder to kill when the plants have matured.

Variegated thistle is distinguished by its large green leaves with cream or yellow to light green blotches and a large purple single flower surrounded by long spiny bracts.

It reproduces from seeds which remain viable in the soil for up to nine years. Long-term control relies on having good pasture which will compete with the thistles for light, nutrients and moisture.

**Control**

Variegated thistle is a declared plant and all infestations should be reported to the Agriculture Protection Board. They will help you formulate an effective control program.

Control is difficult because there are often several germinations each season. For large infestations in clover based pasture, the spray-graze technique is recommended. This involves spraying with 1.5 L/ha of 2,4-D amine as soon as the clover has 6-8 leaves (e.g. late May) and then stocking the paddock at four to five times the normal stocking rate seven days later. This is repeated in August to control late germinations.

MCPE (500 g/L) is only effective at 1.5 L/ha. It is more expensive than 2,4-D but often causes less clover damage. Herbicide rates need to be doubled or tripled for control of large vegetative thistles and this usually damages the clover. Mixtures of 50 mL/ha Lontrel® plus 1 L/ha MCPE (500 g/L) are also effective but often damage clover where the spray overlaps. In medic based pastures Medicamine® should be used instead of 2,4-D amine to reduce damage to the medics. For smaller infestations, where loss of the legume component from the pasture can be tolerated, Lontrel® at 300 mL/ha is more effective. This is normally applied in June or July.

Lontrel® is the preferred herbicide for control of variegated thistles in cereal and canola crops. Lupins or peas should not be planted in variegated thistle infested paddocks because there are no effective control techniques.

If infestations have not been sprayed early in the season then seed set may be reduced by repeated slashing after the stem has elongated but before flowers have formed. Slashing after flowering is ineffective as seed will mature on the reserves present in the slashed stem.

At flowering the production of viable seed can be reduced by spraying with Reglone®, paraquat or Spray.Seed® at 2 L/ha.

Individual plants can be controlled by spot spraying with 100 mL glyphosate (450 g/L) per 10 litres of water or 25 mL Lontrel® per 10 litres of water. Lontrel® is preferred for early spraying because it will also control germinations occurring after spraying. Glyphosate is more effective than Lontrel® after the stem has started to elongate.

2,4-D amine and Medicamine® are hormone herbicides and a permit from the local Department of Agriculture is required before spraying in areas where vegetables or vines are grown.