Cultural weed management

Rotations with pulses

The number of weed seeds in the seed bank can be effectively reduced with a well-planned crop rotation. The more varied the rotation, that is, the more types of crops grown, the easier weeds are to manage.

Including a pulse crop (e.g. field peas) in a cereal and canola rotation can build a complementary weed management system. Difficult to control broadleaf weeds can be managed in the cereal crop and grass weed densities can be reduced in the pulse and canola crops. For example, barley grass and brome grass can be managed in a field pea crop using a combination of:

- a pre-sowing, non-selective knockdown herbicide (the late sowing of field peas allows more weeds to germinate before a knockdown herbicide is applied),
- a competitive variety such as Morgan,
- an in-crop herbicide, and
- crop topping.

A similar well-planned mix of techniques can be used to manage many weeds in other pulses used in the crop rotation.

Rotations with forage legumes

Pulses can also be grown for forage, known as forage legumes. They provide an alternative to the traditional pulse break crop, but still provide nitrogen, disease and weed control benefits to the following cereal crop. Instead of harvesting for grain, forage legumes can be cut for silage or hay, or green/brown manured.

The most commonly grown forage legumes are vetch and field peas (Table 8). Both provide large quantities of dry matter, beneficial for fodder production, nitrogen input and weed competition. In higher rainfall areas, a small quantity of oats sown with the forage can provide a standing frame to reduce lodging and disease as a result of the bulk of dry matter.

The option of cutting for silage or green/brown manuring before weed seed set also provides an effective tool for weed management, including management of herbicide resistant weeds. The success of this method relies on the timeliness of cutting or manuring. It must be carried out before weeds have set seed. There is often a compromise between optimum dry matter production from the forage crop and weed maturity. For this reason, hay cuts are usually not as effective in reducing weed numbers due to the later cutting time. To further reduce weed carry-over to the following year, any later maturing weeds must also be controlled after cutting, eg through heavy grazing or preferably chemical control.

Forage legumes can be cut for silage which can help to manage weeds before they set seed.
Photo: Kirrily Condon

Table 8 Characteristics of large seeded forage legumes

Forage legume	Optimum pH ($CaCl_2$)	Optimum rainfall	Sowing rate (kg per ha)	Comments
Vetch (eg. Popany)	> 4.5	> 400 mm	40	Tolerant of acid soils and sodic subsoils Suited to light & heavy textured soils Popany is a soft seeded variety Inoculant group E
Field pea (eg. Morgan)	4.5 to 8.0	> 350 mm	70 to 100	Suited to light & heavy textured soils Morgan is a vigorous, bulky variety Morgan has small seeds, therefore low seed rate Inoculant group E

Research highlight

Forage legumes and weed management

Trials at Wagga Wagga in southern NSW have shown large seeded legumes, such as vetch or peas, used as a forage can provide excellent weed control when dry matter production is high (see table below) and may be a useful tool for the management of herbicide resistant weeds such as annual ryegrass.

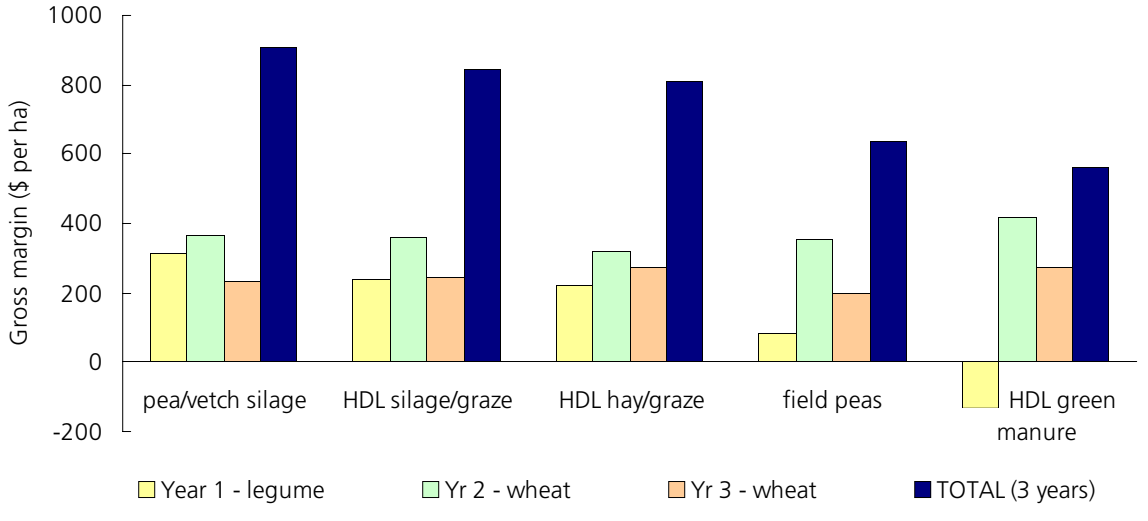
Returns from forage legumes cut for silage or hay can be superior to those from pulses harvested for grain (see graph below). However, economic benefits rely on the capacity of the grower to use or sell large quantities of silage or hay.

Although green or brown manuring forage legumes can result in increased yields in the following crop(s) from additional nitrogen, this is often not enough to make up for the lack of returns from the initial manuring.

Annual ryegrass germination in autumn following a forage legume break crop or use of high density legumes (HDL).

Crop	Treatment	Annual ryegrass plants per m^2
Vetch	Green Manure	44
HDL	Green Manure	29
Vetch	Silage	44
HDL	Silage	107
HDL+graze	Silage	16
Pea	Silage	401
HDL	Hay	634
HDL+graze	Hay	549
Lupins	Grain	1145
Peas	Grain	721

Summary of economic analysis of various legumes followed by two wheat crops in a weed free situation. HDL is a high density legume mixture used either for silage or hay production.



Condon (1999)

Making decisions on the run!

Farmer: Graham and Michael Sinclair.

Location: Temora, southern NSW.

Property size: 1520 ha.

Annual rainfall: 535 mm.

Soil type: Red brown earth, ranging from sandy loam to clay loam.

Main enterprises: Winter cereals, canola, pulses, 1800 merino and 1st cross ewes, which are joined to produce prime lambs, fattening store lambs (2000 - 3000 lambs a year) and a 40 cow breeding herd. Pastures are lucerne, perennial grass and clover.

During the 2002 drought Graham and Michael had 96 ha of Excell field peas. The field pea growth was good through winter and early spring, and they were podding well, considering the tough conditions. A severe frost occurred when the pods were at 'flat pod' stage, damaging the majority of seeds and causing significant yield loss. As drought conditions prevailed, and stockfeed demand soared, they changed their plans and made the decision to cut the crop for hay. There was an estimated 2 t per ha dry matter, a poor yield outlook due to the frost damage and lack of rain, and a ready and growing market. The hay cut would also have a significant effect on weed seed production, in particular, herbicide resistant annual ryegrass. No post hay-cut application of knockdown herbicide was needed in this case due to the lack of rain and heavy grazing.

Another option with field peas is baling for hay. If production of seed is limited by frost or disease the crop can be cut and baled producing high quality forage. This adds another management strategy to controlling herbicide resistant annual ryegrass.

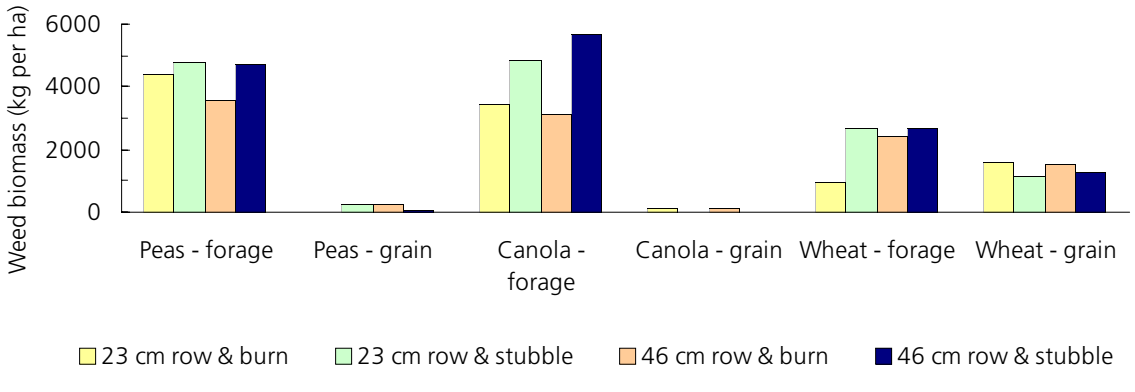
Research highlight

Using forage conservation to manage weed burdens

Continuing research at Wagga Wagga, southern NSW aims to determine the influence of row spacing, stubble management and crop type on both the short-term gross margin and the weed seed bank. Two weed management systems were compared, a low herbicide input, forage production system and a best-practice grain production system.

In the low input forage production system weed biomass was much higher than in the grain production system (see graph below). However weed seed addition into the soil seed bank was substantially reduced by cutting and baling the low input field peas for hay.

Influence of crop species and tillage practice in forage and grain production systems on weed biomass.

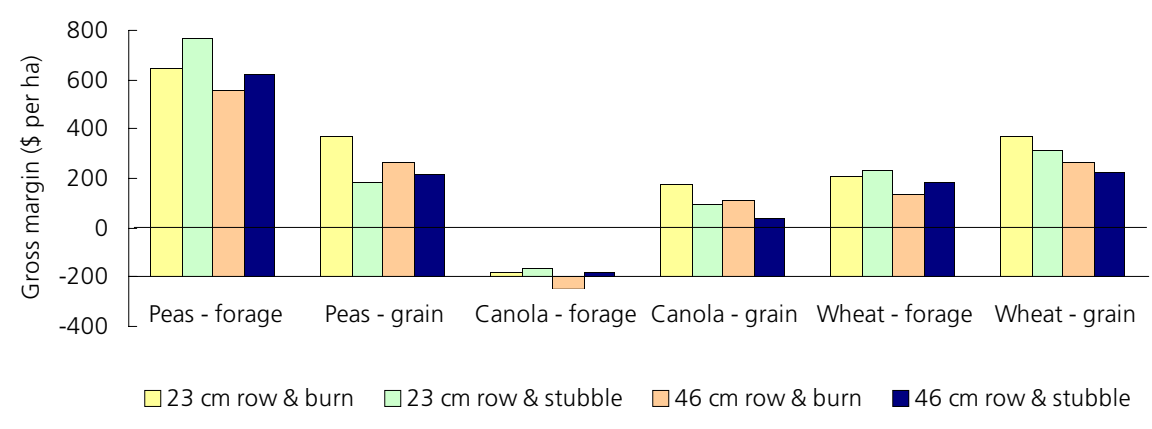


The highest gross margin was achieved in the field pea forage system with 23 cm rows and stubble retained, approximately $700 per ha. See graph below. Field pea, grain returned approximately $400 per ha, with mean field pea grain yield 2.42 t per ha.

Preliminary results show that it is possible to make profits and minimise weed seed bank replenishment, depending on crop species, in both conventional and conservation farming systems.

Baling crops with high weed burdens can significantly reduce weed numbers in the following seasons. Weed seed sterilisation is important.
Photo: Eric Koetz.

Influence of crop species and tillage practice in forage and grain production systems on crop gross margins.



Lemerle *et al.* (2002)

Stubble management

The management of the previous year's cereal stubble is a crucial step in managing weeds in the pulse crop. There are a number of management options that can be used to reduce the weed seed number in cereal stubble.

No grazing

No grazing leaves the weed seeds on the soil surface and in amongst the stubble. This is a less favourable place for them to germinate and become established than in the soil after being trodden on by livestock. Burning the stubble in this situation will reduce the weed seed bank even further.

Stubble burn

A cool stubble burn late in the autumn will not kill as many weed seeds as a hot burn, however it will have a significant impact on weed seed numbers, especially if the stubble has not been grazed.

No straw spreaders and hot burn

This method has been used by growers NSW as another tool for managing herbicide resistant annual ryegrass. The straw spreaders are removed from the header at harvest time leaving the chaff and weed seeds in a windrow. When these are burnt the hot fire kills a large percentage of weed seeds.

Collecting straw and chaff from the header

Growers have been successfully managing herbicide resistant annual ryegrass and other weeds by collecting the chaff in carts attached to the back of the header. The cart is emptied in the paddock leaving heaps which are burnt, killing most of the weed seeds due to the high temperature. Further techniques are being developed to bale the chaff and use it as feed for intensive livestock production, avoiding the need to burn.

When using any of these techniques it is vital to mix them up. Never use the same method in a paddock repetitively. This will lead to selection of weeds which can avoid the technique eg early maturing ryegrass plants will not be controlled by chaff collection at harvest so using it again and again in the same paddock will result in a predominantly early maturing ryegrass population. Use of a cereal stubble burn will reduce the seed numbers of these early maturing plants.

A late stubble burn can be effectively used as part of a weed management plan (particularly when herbicide resistance is present). If the heat is high enough, weed seeds at or close to the soil surface are destroyed or sterilised. More seeds are killed if the paddock has not been grazed and all seeds are sitting on the soil surface.

One strategy used by Mark Branson in South Australia to control annual ryegrass in the canola phase of his rotation is to disconnect the straw spreaders at harvest. All the crop residue and the weed seeds fall into a windrow and can later be burnt, reducing the weed seed bank. *See page 19 On-farm Solution.*

Management of windrows is essential to prevent a future weed problem occurring in the paddock. In this paddock, the weed seed in the windrows was not managed to prevent additions to the seed bank and weeds emerging the following season were concentrated in the old windrows. The Paterson's curse flowering in the windrows needs to be controlled to prevent seed set.

On farm solution

Managing resistant ryegrass at harvest - a chaff cart and baling system

Farmer: Paul & Brendan I'Anson.

Location: Burrumbuttock, southern NSW.

Property size: 2500 ha.

Annual rainfall: 550 mm.

Soil type: Mix including red brown earth, grey clay and loams.

Main Enterprises: 90% crop, with small number of merino lambs - wheat, triticale, canola, field peas and lupins.

In 1996 Paul and Brendan began developing a chaff cart for their header as a tool to manage herbicide resistant annual ryegrass. The chaff and weed seeds, but not the straw, are collected in a cart and dumped in heaps 'on-the-go' during harvest. Header capacity and harvest speed are maintained. The heaps are later baled using a large square baler and sold for use in beef and dairy cattle feed rations.

The 'chaff bales' have similar feed value to wheat straw but do not need chopping. In comparison to baling straw, no windrow operation is required so the cost is reduced making the economics much better.

Paul has noticed a dramatic decline in annual ryegrass plant numbers as well as wild radish. Wild oat numbers are not being reduced and the process may be selecting for early shedding wild oat plants which escape the chaff cart. Alternate methods such as crop-topping are being employed to target wild oats.

The header is fitted with a 'slinger' (above and left) to collect and feed the chaff and weed seeds into the collection cart. The engineering of the slinger was the key to success and required some fine tuning.
Photos: Steve Sutherland

The chaff (and weed seeds) collected in the cart during harvest are dumped on-the-go in the paddock. They are then baled and the bales sold for cattle feed in dairies or feedlots. The chaff piles can be placed outside the paddock to avoid weed seeds remaining where the dumps were.
Photos: Paul I'Anson

case study...

Managing resistant ryegrass at harvest - a direct baling system

Farmer: Michael Shields.

Location: Wongan Hills, Western Australia.

Property size: 9000 ha.

Annual rainfall: 361 mm.

Soil type: Sand plains.

Main Enterprises: 100% crop - wheat, lupins, barley, canola.

'Glenvar' was established in 1925 by the Shields family and has grown to accommodate the growing family business and their employees. In 1981 the property became focused solely on cropping (wheat/lupin rotation using full cultivation). By the end of the decade, minimum tillage was primarily used.

The introduction of barley into the rotation (lupins/wheat/barley/wheat/lupins) extended the simple lupin/wheat rotation. However, after 1995, the problem of herbicide resistance was identified. A more integrated approach to weed management was then investigated by the Shields. This began with the importation from Canada of a 'Redekop' system of chaff collection (ie using chaff carts at harvest) which enabled the capture of mature weed seeds in the chaff. In association with harvest innovations, air seeders were used at sowing to improve precision and placement of seed and fertiliser. Canola was also introduced into the rotation. Swathing (or windrowing) was another practice used at harvest to aid with weed control. Burning the rows of straw and chaff or the chaff piles in early autumn helped to remove weed seeds from the soil seed bank.

To further improve weed control via seed collection, a small baler system, towed directly behind the header, was used during the 2000 harvest. The baler collected the entire crop residue (including weed seeds). It was anticipated that between 3000 and 4000 bales (40 to 50 kg) would be produced. However at the end of harvest the number of bales far exceeded these estimates (68000 lupin bales and 31000 wheat bales). The success of the baler project relied on extensive trialing and baler modifications. This included: a tow hitch assembly; strengthening of harvester chassis; purpose designed conveyor system and collection tray; independent power source for baler; larger wheels; purpose built air intakes; and a video camera system. The small baler system was quite labour intensive (thus increasing costs) and in 2001 a larger square baler system was trialed.

The larger bales (3 x 4 x 8 foot, weighing 400 kg) were produced and transported directly from paddock to pellet processing mills. The more efficient system of residue removal reduced costs and also improved the management of herbicide resistance in the cropping program. The Shields' approach to the management of herbicide resistance on their property has been one that incorporates various cultural and mechanical aspects of weed management and highlights the need to use dynamic, innovative and strategic methods to find solutions to weed control. (Visit www.glenvar.com)

case study...

Research highlight

Burning stubble, chaff piles and narrow windrows

There are a number of ways to collect weed seeds with a header.

- Set the machine to collect weed and crop seed (weed seeds can be cleaned out later).
- Use a machine equipped with a grain cleaner.
- Remove straw spreaders and create narrow header trails (to be burnt later).
- Use a header equipped with a chaff cart.

Windrowing the crop before threshing is a useful technique if the weeds will shed seed before the crop is mature, enhancing all of the above techniques (see Table below).

Impact of windrowing on the efficacy of ryegrass seed collection at harvest measured as ryegrass seedling number per m^2 the following autumn.

Ripe crop treatment	Seedlings per m^2	Control %
Harvest, chaff spreader	721	0
Harvest, chaff cart	256	65
Windrow, harvest, chaff cart	67	91
Harvest, narrow windrow (burnt)	543	25
Windrow, harvest, narrow windrow (burnt)	131	82

Roy (1999)

Take note

Burning, weed seeds and livestock

The impact on weed seed survival when burning chaff piles or narrow windrows is reduced by grazing because weed seeds are pushed into the soil where they are protected from a hot burn and are spread around the paddock or grazed area.

Hygiene on the farm

The introduction of weed seed to a paddock is a major production issue. Contamination of paddocks with new sources of weed seed can readily occur via:

- the purchase and use of contaminated seed
- the use of poorly cleaned, retained seed
- the movement of farm vehicles, machinery and livestock between farms and paddocks
- the use of unclean storage, seed grading or handling facilities
- the feeding out of contaminated grain, hay and silage.

It is therefore important to ensure all these potential sources are considered when developing a simple yet strict weed hygiene risk management strategy.

To reduce the possibility of introducing weed seeds the following steps should be taken.

Know what you sow!

- Check your seed source prior to sowing - are you satisfied with what you are going to introduce into your paddock? Seed bought over the fence is fine as long as you are fully aware of the weeds that were present in the paddock where it was grown as well as on the farm. Remember seed from a relatively weed free paddock can easily become contaminated with problem weeds through lack of care at harvest and with subsequent handling.
- Seed that has been saved and kept 'on-farm' from previous years should only be cleaned at a reputable seed cleaner. Check with the cleaner to ensure that the plant can specialise in pulse seed and has the appropriate screens for processing such crops. Check also that cleaned seed is transferred to clean silos and or clean

Volunteer crops like this canola in a lupin crop can be a significant weed contamination problem in farmer kept seed and delivered grain. They should be treated as a serious weed, the same as 'traditional' weeds in a cropping system.
Photo: Steve Sutherland

Research highlight

Know what you sow! Lessons from Victorian seed box surveys.

Seed box surveys of field crops in Victoria during 1996, 1997 and 2001 found a wide range of seed contamination. The majority of the pulse crop seed was farmer saved or purchased 'over the fence' and contained more weed seeds than purchased certified seed.

The five main weed contaminants in pulse crops were volunteer pulses, volunteer cereals, wild oats, wild radish and pasture legumes (*Medicago* spp., *Trifolium* spp. and *Melilotus indicus* (L.) All.).

- 40% of pulse crops met Victorian certified seed standards. Of these, only 25% were weed free.
- Of the 60% of pulse crops that did not meet Victorian certified seed standards, 23% (of the total) were due to volunteer crop and 37% to weed contamination.
- 63% of lentils, 54% of beans, 38% of field peas, 21% of lupins and 20% of chickpea seed met Victorian certified seed standards.

Weed seeds per kg	Percentage of samples
0	18
1-4	32
5-15	25
> 15	25

In lentils, annual ryegrass was the most problematic weed contaminant and vetch, bedstraw and volunteer crops were also potential problems.

Moerkerk (2002); Roya Niknam *et al.* (2002)

(preferably new) bags. If the seed is to be delivered in bulk ensure that all augers, silos and trucks are free from weed contaminants.

- Buy quality seed - it is important to determine the amount and type of weed seeds that could be present. Any reliable merchant will provide details of weed seed present and contamination levels. Don't introduce a herbicide resistance problem.
- Beware – purchasing certified seed is not a guarantee of freedom from weed infestation. Certified seed may contain weed seed. The statement of analysis will list the weeds present and the levels at which they occur. The analysis certificate will also list declared and prohibited weeds. This information is not on bag tags so obtain the certificate from the merchant and read it carefully before purchasing the line of seed.

Run a clean operation

- Thoroughly clean harvest, tillage and sowing equipment between farms, paddocks and different types of crops. This includes all contract harvesting equipment. Clean down procedures need to be more than a superficial once over. All removable screens and collection points should be individually checked. Care should also be taken to clean equipment down in an area unlikely to create further contamination problems.
- Begin any sowing or harvesting operations in the cleanest (least weedy) paddock as this will reduce weed contamination and spread. Avoid harvesting close to high traffic areas such as gateways and stock camps.

Plan stock feeding

- When introducing new stock allow them to 'empty out' before moving them to clean paddocks to reduce weed cross-contamination. If possible, feed known weed infested fodder in the paddock from which it was obtained or in a quarantined area.
- Ideally, buy hay or grain that contains minimal weed seed.

Remember, crop hygiene equals CLEAN:

Check harvest & tillage equipment

Limit weed seed movement by livestock

Employ a sowing & harvest paddock risk strategy

Avoid feeding contaminated grain or hay

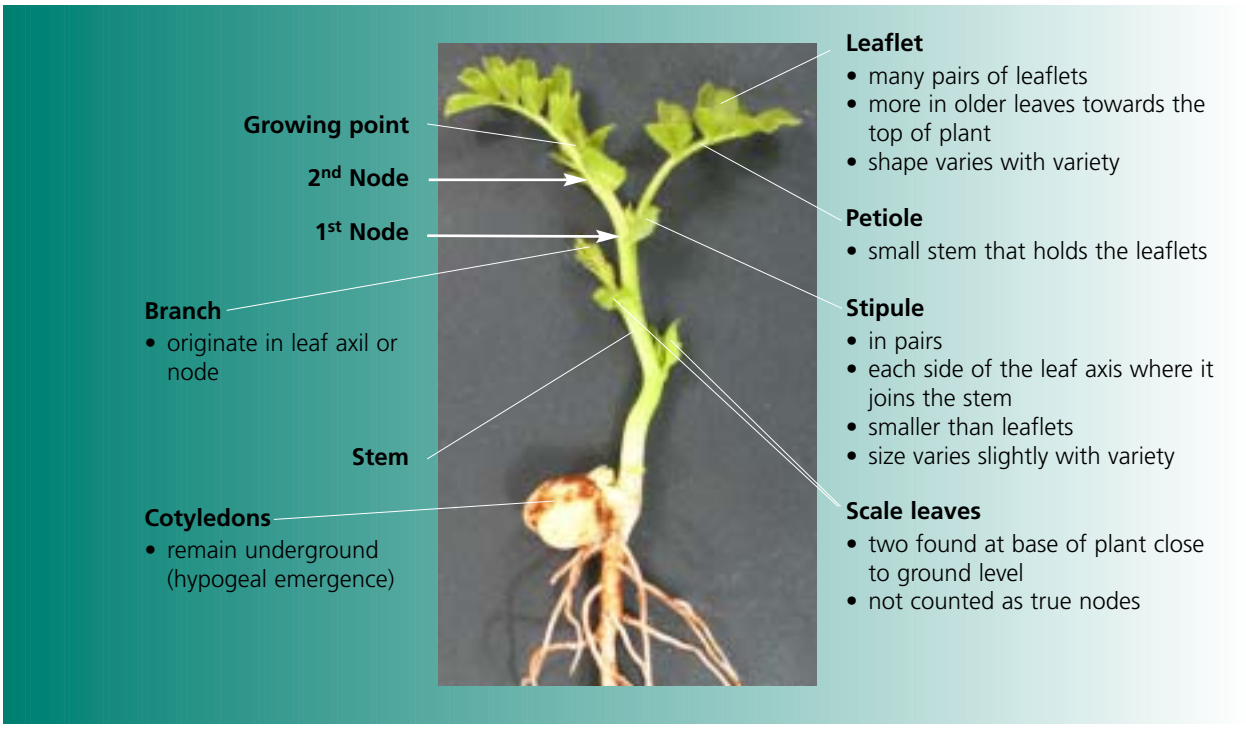
Never sow contaminated seed

Take care when feeding hay roles. Feeding out across the paddock like this risks spreading weed seeds, including herbicide resistant annual ryegrass, across a whole paddock or farm.
Photo: Brian Cumming

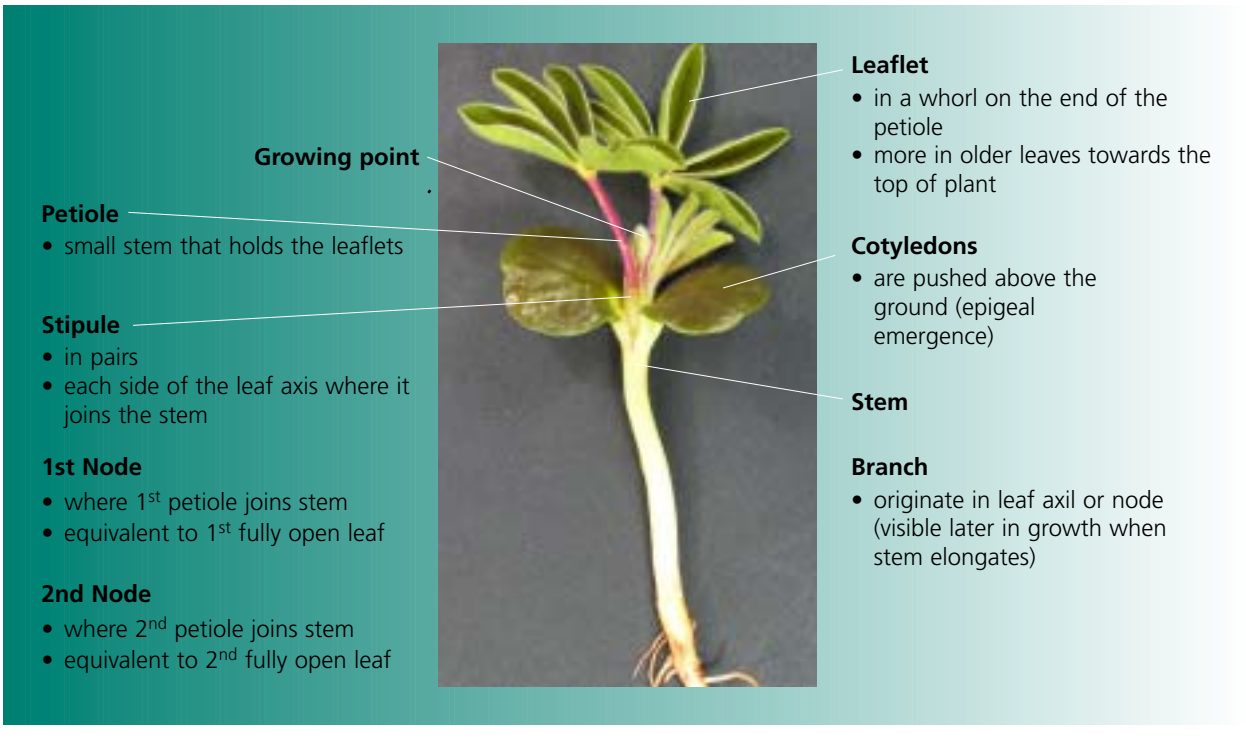
Appendix 1 ~ Crop growth stages

All pulse species have the same basic structure based on a main stem which can be divided into basic units known as nodes. Two scale leaves appear first and the nodes where they occur are not counted as true nodes. A node is made up of a petiole which has stipules where it joins the stem, and leaflets along its length. In some species it terminates in a simple or more complex tendril.

Chickpea (*Cicer arietinum*)

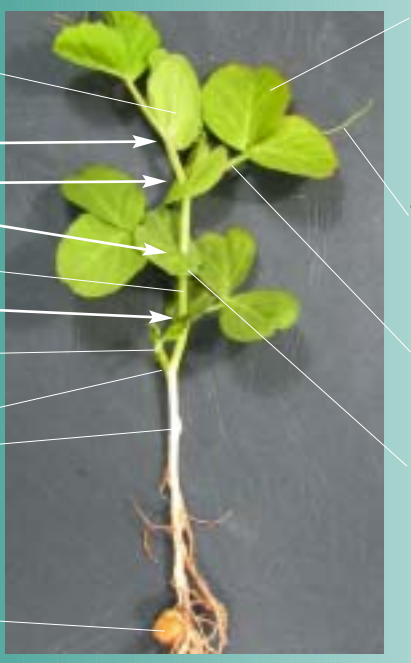


Lupin - albus (*Lupinus albus*), pictured, and narrow-leafed (*L.angustifolius*)



Field pea - conventional leaf type (*Pisum sativum*)

e.g. Dundale, Parafield, Alma.



Growing point
- inside stipules

4th Node

3rd Node

2nd Node

Stem

1st Node

Branch
- originate in leaf axil or node

Scale leaves
- two found at base of plant close to ground level
- not counted as true nodes

Cotyledons
- remain underground (hypogeal emergence)

Leaflet
- 1 to many pairs of leaflets depending on variety
- more in older leaves towards the top of plant
- size and shape varies with variety

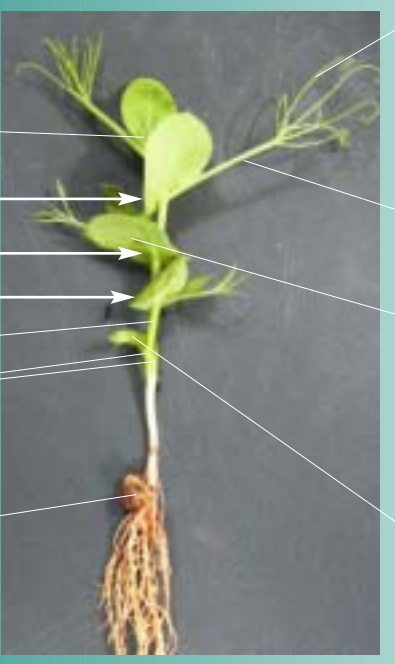
Tendrils
- simple in young leaves, more complex in older leaves towards the top of plant

Petiole
- small stem that holds the leaflets, terminating with a tendril

Stipule
- in pairs
- each side of the leaf axis where it joins the stem
- size varies with variety

Field pea - semi-leafless type (*Pisum sativum*)

e.g. Kaspa, Excell, Snowpeak, Mukta, Morgan.



Growing point
- inside stipules

3rd Node

2nd Node

1st Node

Stem

Scale leaves
- two found at base of plant close to ground level
- not counted as true nodes

Cotyledons
- remains underground (hypogeal emergence)

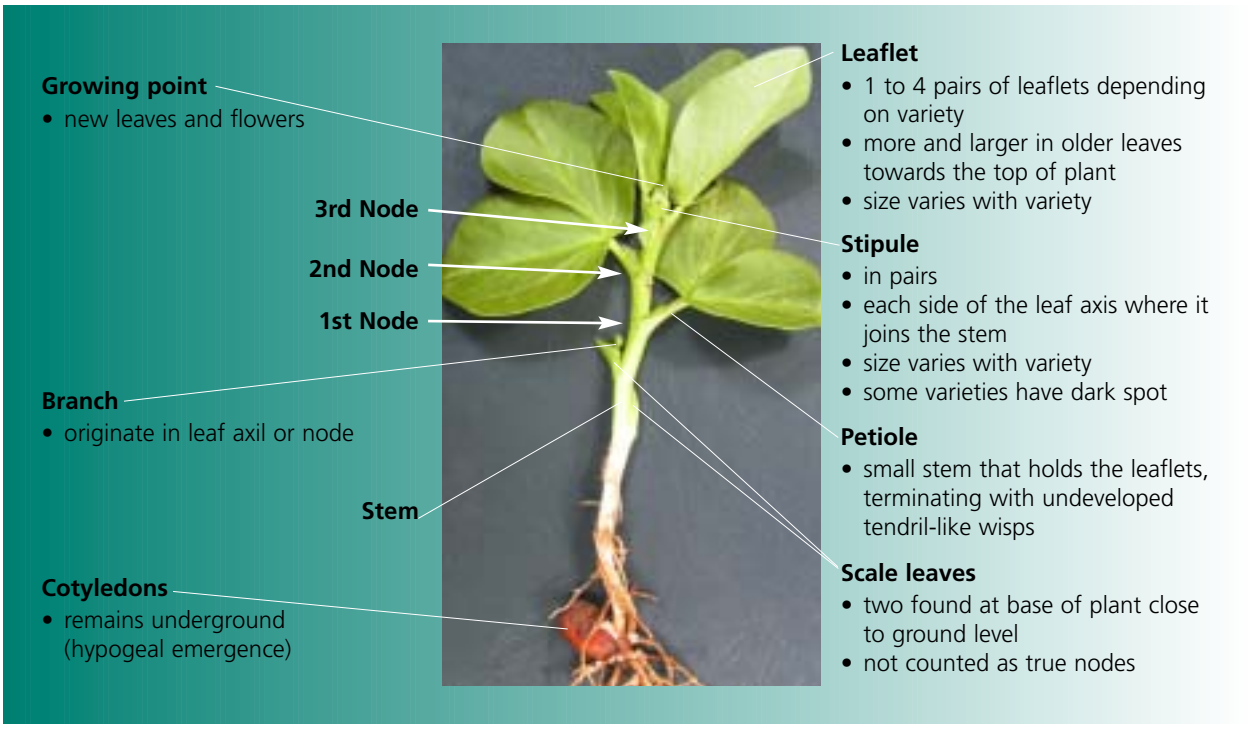
Tendrils
- well developed in semi-leafless field peas
- simple in young leaves, more complex in older leaves towards the top of plant

Petiole
- small stem that terminates with a well developed tendril

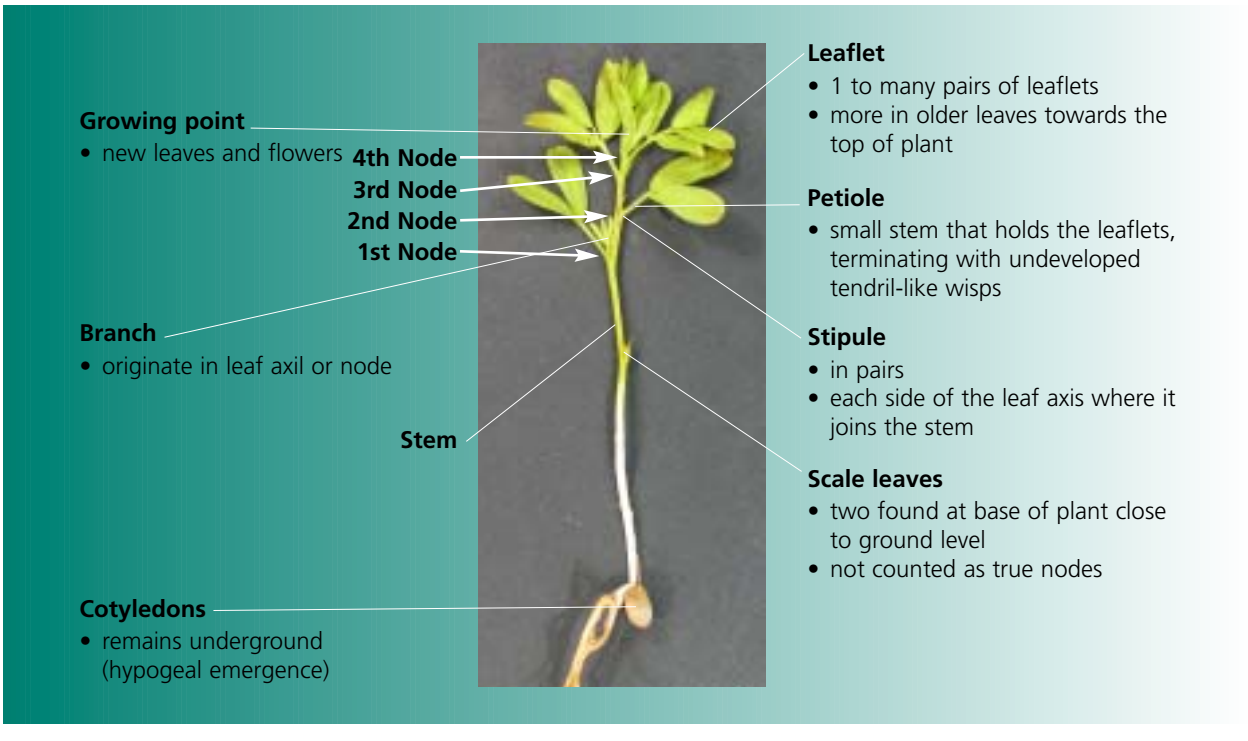
Stipule
- in pairs
- each side of the leaf axis where it joins the stem
- size much larger than in conventional leaf types

Branch
- originate in leaf axil or node

Faba bean (*Vicia faba*)



Lentil (*Lens culinaris*)



Appendix 2 ~ Glossary of terms

Active ingredient is the component in a herbicide (or pesticide) which actively affects a plant growth function in the targeted weed species.

Anthesis is flowering.

Banding is when fertiliser is placed under the soil surface in a concentrated band using a tube attached to a cultivating tine.

Broadcast refers to being spread on the surface eg fertiliser.

Broadleaf weed is any broadleaf plant (dicotyledon) which is growing where it is not wanted.

Brown manure is when a non-selective herbicide is applied to stop all plant growth. Similar to green manure but uses herbicide.

Cation exchange capacity (CEC) is the sum of the exchangeable cations (calcium + potassium + aluminium + sodium). The higher the clay or organic matter content of the soil, the higher the CEC.

Cotyledon is the seed leaf, formed directly from the embryo. Stores food and is the largest part of a seed.

Crop topping is the application of a non-selective herbicide to sterilise weed seeds. Timing is dependent on weed growth stage not the crop.

Desiccation is the application of a non-selective herbicide to stop crop growth, and even and speed up the maturity. Timing is dependent on crop growth stage.

Electrical conductivity is a measure of salinity. In soil, there is a risk of salinity problems if EC is greater than 2 dS/m.

Epigeal emergence is seed germination when the cotyledons are raised above the ground surface. Opposite of hypogeal. *See diagram page 20*.

Grass weed is a grass plant (or monocotyledon) growing where it is not wanted.

Green manure is when crop or pasture is killed by cultivation in the early reproductive stage of growth and left *in situ* to add organic matter to the soil.

Hand roguing is the process of removing by hand small populations of weeds from an area.

Harvest index is the ratio of grain to total dry matter produced (grain plus straw).

Herbicide group identifies herbicides with a similar mode of action. Some groups have a high risk of herbicide resistance problems (Group A, B), while others have a moderate risk (Group C, D, E, F, G, H), and others a low risk (Group I, K, L,M, N). *See Table 6 page 28*.

Herbicide resistance is the inherited ability of a plant to survive and reproduce following the exposure to a dose of herbicide that would normally be lethal to the wild type. It may occur naturally due to selection pressure or be induced by techniques such as genetic engineering.

Hypogeal emergence is seed germination when the cotyledons remain beneath the ground surface. Opposite of epigeal. *See diagram page 20*.

Incorporate by sowing (IBS) refers to herbicides which are applied prior to sowing and are then incorporated by sowing. Some herbicides require this incorporation in order to be effective.

I**noculant** is a culture of an organism (eg *Rhizobia* bacteria). Used as a seed dressing or injected directly into the soil at sowing causing nitrogen fixing nodules to be formed.

Moisture seeking is a technique used to sow a crop when soil is dry on the surface and moist at depth. Usually the seed is sown into the moist soil and dry soil is moved aside leaving a furrow. The seed may be sown 10 or 15 cm below the level of the soil surface but because of the furrow the effective seeding depth is only 5 cm.

Non-selective herbicide is a herbicide which affects most herbaceous plants and therefore does not selectively kill one species.

Nutrient is essential for plant growth and development.

Macro nutrients required in large amounts for plant growth:

Ca - calcium	N - nitrogen
K - potassium	P - phosphorus
Mg - magnesium	S - sulphur

Micro nutrients are required in very small or trace amounts for plant growth:

Al - aluminium	Fe - iron
Bo - boron	Mn - manganese
Cl - chlorine	Mo - molybdenum
Cu - copper	Zn - zinc

Plant target density is the desired number of plants per unit area. Used to calculate seeding rate.

Physiological maturity is the point in time when all growth processes of a plant have ceased and it is dehydrating.

Post-emergent refers to the time after the crop or weed has emerged. Used when referring to the timing of herbicide application, those applied after the crop has emerged.

pH ($CaCl_2$) is a measure of acidity (less than 7) or alkalinity (greater than 7) using a calcium chloride test. pH can also be measured using a water test. In soil, a pH less than 5 may encounter acidity problems. pH 5 to 7 is ideal for growth of most plants. A soil above 7 may encounter alkalinity problems.

Post-sowing pre-emergent refers to the time after the crop has been sown but before it has emerged. Used when referring to the timing of herbicide application, those applied after sowing but before the crop has emerged.

Pre-emergent refers to the time before the crop has emerged. Used when referring to the timing of herbicide application, those applied before the crop has emerged.

Rhizobia are bacteria involved with legumes in a symbiotic relationship that results in nitrogen fixation. They form nodules on the roots of pulse and other legumes.

Salvage knockdown is a herbicide applied to a crop to control very late weed growth. It will also kill the crop. If it is timed to coincide with crop maturity it will not affect yield, but will act as a harvest aid.

Selective herbicide is a herbicide which will selectively kill one species without affecting another.

Top dressing is the application of a fertiliser to the soil surface, usually during crop growth.

Water use efficiency is a measure of how efficiently a plant uses available soil water for growth and development. It is often quantified as kg of grain produced per mm of available water.

Windrowing is the mechanical cutting of a crop (or pasture) to stop growth, and even and speed up the maturity. Timing is dependent on crop growth stage.

Appendix 3 ~ Further information

Publications

National and regional publications

Chickpea: management strategies for central and southern NSW. Pulse Australia (annual).

Faba Bean Disease Management Strategy For Southern Region GRDC. Pulse Australia (annual).

Field Crop Herbicide Guide (Kondinin)

Field Crop Insecticide Guide (Kondinin)

Field Pea Disease Management Strategy For Southern and Western Region GRDC. Pulse Australia (annual).

Grain Legume Handbook for the pulse industry (Eds. John Lamb and Anita Poddar).

Lentil Disease Management Strategy For Southern Region GRDC. Pulse Australia (annual).

Lupin Development Guide (University of Western Australia Press)

Weeds: The ute guide (Topcrop Australia).

Winter Pulse Disorders: The ute guide (TOPCROP Australia).

New South Wales

NSW Department of Primary Industries has the following crop management guidelines available from district offices or the internet:

Best practice management for sustainable production: chickpea. NSW Agriculture Agfact P4.2.2.

Best practice management for sustainable production: faba bean. NSW Agriculture Agfact P4.2.7.

Best practice management for sustainable production: field pea. NSW Agriculture Agfact P4.2.9 (currently being updated).

Best practice management for sustainable production: lupin. NSW Agriculture Agfact P4.2.17.

Desiccation and harvest of field peas (Pulse Point 5).

Weed control in winter crops (annual) ISSN 0812-907X.

Windrowing lupins (Pulse Point 9).

Windrowing faba beans (Pulse Point 10).

Winter crop variety sowing guide. Agdex 110/10 (annual).

Queensland

Queensland Department of Primary Industries has the following crop management notes available on a CD or the internet:

Chickpeas: a guide to chickpea production in Queensland.

Faba Beans: a guide to faba bean production in Queensland.

Field Peas: a guide to field pea production in Queensland.

Heliothis Management in Chickpea.

Lentils: a quick guide to lentil production in Queensland.

Lupins: a quick guide to lupin production in Queensland.

South Australia

Primary Industries South Australia has the following crop management guidelines available from district offices or the internet:

Growing Chickpeas PIRSA Fact Sheet.

Growing Faba Beans PIRSA Fact Sheet.

Growing Field Peas PIRSA Fact Sheet.

Growing Grain Vetch PIRSA Fact Sheet.

Growing Lentils PIRSA Fact Sheet.

Growing Lupins PIRSA Fact Sheet.

PIRSA Rural Solutions Crop Harvest Report (annual).

SA Crop Variety Sowing Guide (annual).

South Australian Field Crop Evaluation Program - Post Harvest Report (annual).

Victoria

Victorian Department of Primary Industries has the following crop management guidelines available from district offices or the internet:

Ascochyta Blight of Field Peas, Agriculture Victoria AGNOTE AG0150.

Ascochyta Leaf and Pod Spot on Faba Beans, Agriculture Victoria AGNOTE AG0151.

Bacterial Blight of Field Peas, Agriculture Victoria AGNOTE AG0148.

Brown Leaf Spot and Root Rot of Lupins, Agriculture Victoria, AGNOTE AG0120.

Chickpea Growers Guide: A Guide to the Production of Chickpeas (Agriculture Victoria - Horsham).

Chocolate Spot of Faba Beans, Agriculture Victoria AGNOTE AG0153.-

Cucumber Mosaic Virus of Lupins, Agriculture Victoria, AGNOTE AG0398

Downy Mildew of Field Peas, Agriculture Victoria AGNOTE AG0149.

Earth mites, Agriculture Victoria AGNOTE AG0414.

Faba Bean Growers Guide: A guide to the production of faba beans (Agriculture Victoria – Horsham).

Field Pea Growers Guide: A guide for the production of field peas (Agriculture Victoria – Horsham)

Growers Guide to Assessing Nodulation in Pulse Crops (Natural Resources and Environment TOPCROP).

Lentil Growers Guide: A guide for the production of lentils (2nd ed) (Agriculture Victoria – Horsham).

Lucerne Flea, Agriculture Victoria AGNOTE AG0415.

Native Budworm, Agriculture Victoria AGNOTE AG0417.

Pea Weevil, Agriculture Victoria AGNOTE.

Phoma Blight of Chickpeas, Agriculture Victoria AGNOTE AG0452.

Powdery Mildew of Field Peas, Agriculture Victoria AGNOTE AG0147.

Rust of Faba Beans, Agriculture Victoria AGNOTE AG0152.

Sclerotinia of Chickpeas, Agriculture Victoria AGNOTE AG0453.

Western Australia

Department of Agriculture Western Australia has the following crop management guidelines available from district offices or the internet:

Common vetch production technology. DAWA Technical Bulletin 4444.

Crop Variety Sowing Guide. DAWA Technical Bulletin 4566 (annual).

Essential Management Cards for Field Peas, Lentils, Faba Beans, Chickpeas and Disease Management for Chickpeas

Growing Field Peas. Bulletin 4239.

Identification and Management of Foliar Diseases of Chickpeas. Farmnote 79/2002.

Producing Lupins in Western Australia. Bulletin 4179. ISSN 0729-0012.

Successful Field Pea Harvesting. Bulletin 4569.

The Chickpea Book. Bulletin 1326.

Websites

www.weeds.crc.org.au	CRC for Australian Weed Management (Weeds CRC)
www.dpi.nsw.gov.au	NSW Department of Primary Industries
www.dpi.qld.gov.au	Queensland Department of Primary Industries
www.sardi.sa.gov.au	South Australia Research and Development Institute
www.pir.sa.gov.au	Primary Industries and Resources (South Australia)
www.dpi.vic.gov.au	Department of Primary Industries (Victoria)
www.agric.wa.gov.au	Western Australian Department of Agriculture
www.csiro.au	CSIRO
www.grdc.com.au	Grains Research and Development Corporation
www.pulseaus.com.au	Pulse Australia
www.ipmnet.org	Integrated Pest Management - sponsored by CICP
www.pestgenie.com.au	Chemical labels, Material Safety Data Sheets (MSDS), search products registered for a situation and pest is each State.
www.apvma.gov.au	Australian Pesticides and Veterinary Medicines Authority - search for permits
wahri.agric.uwa.edu.au	Western Australian Herbicide Resistance Initiative (WAHRI)
www.topcrop.grdc.com.au	TopCrop Australia

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