# Chapter 3
# Agronomy

***Compiled by Annie Johnson and Greg Brooke***

Photo: A. Johnson

*Weed free wheat crop.*

### *Integrated Weed Management in cropping*

Maximising yield potential is an important part of Integrated Weed Management (IWM). Weeds have a lesser effect as the crop yield potential increases.

Agronomy aims to optimise crop yield potential. It is used to favour the crop over the weeds by reducing weed growth, minimising seed set and delaying the development of herbicide resistance.

Agronomic options for weed control are often low cost compared to herbicides alone.

When effective agronomic practices are integrated with a tactical herbicide program, the result is a more cost effective weed control program.

Agronomy uses a range of methods to make crops more competitive. Agronomy tools that are discussed in this chapter include:

- Crop density
- Time of sowing
- Herbicide rate and timing
- Crop choice
- Row spacing
- Fertilisers
- Harvest

Issues such as cultivation, hay production, and herbicide choice are discussed in Chapters 1, 4 and 8.

Weeds have the greatest impact in the early stages of crop growth. Crop choice, plant density, row spacing, time of sowing and fertiliser all determine the crops' competitiveness and the yield potential.

### Competitive Crops

Competitive crops are able to suppress weed growth and achieve higher yields. Competitive crops are not reliant on herbicides to maintain yield, however when used in conjunction with herbicides, achieve greater weed control (Case study 3.1) and reduce herbicide selection pressure.

### Case Study 3.1 Management of wild oats and annual phalaris in wheat and barley

Research conducted on the Darling Downs showed that weeds can be controlled in barley with considerably less herbicide than required in wheat.

- Barley has a competitive advantage. In the barley, unsprayed weeds reduced the grain yield but less so than in the wheat.
- A barley crop treated with post-emergent herbicide at only 25% of the standard rate conserved yield and minimised weed seed set.
- In comparison a wheat crop with a post-emergent herbicide at 50% of the standard rate conserved yield but 100% herbicide rate was required to reduce weed seed set.

The crops suppressed the weeds during the vegetative stage resulting in less tillers in the grass weeds. Competition between the weeds and crop is reduced after flowering as the crops and weeds set seed with the remaining tillers.
***Source: Walker et al. 2001.***

### Crop choice

Choose competitive crops for the weediest paddocks. Closed canopy crops such as cereals are more competitive compared with open canopy crops such as pulses (Figure 3.1). Canola is competitive against some grasses as the large base provides ground cover and reduces late weed germination.

Choose the crop that has the most control options for the weeds present. For example, grow cereal crops where broadleaf weeds are a problem and broadleaf crops where grass weeds are a problem.

Some pulses have a short growing season which allows alternate options for weed control such as delayed sowing.

***Figure 3.1 The relative competitiveness of crops against wild oats.***

Barley > wheat > oats > canola > faba beans > field peas > chickpeas = lupins = lentils

***Source: Nugent et al. 1999.***

### Crop density

The density of the crop compared to the weeds will affect the yield potential; this is variable due to moisture availability.

For example, in an average rainfall year a higher crop density may decrease some weed species and maintain yields. Better yields can be achieved in weedy paddocks by using a higher sowing rate when there is plenty of moisture.

In a dry year lack of moisture will lower yields regardless of sowing rate or weed density.

Increased screenings have been found at higher crop densities. However, this is often due to the spacing of the seed within the row, not the actual row spacing. The risk of high screenings can be reduced by sowing on time in paddocks with a low disease risk and ensuring there is adequate phosphorus.

Photo: J. Edwards

***Wild oats in durum wheat.***

### Points to remember

The impact of soil type and seasonal conditions can lead to a large variation in predicted yield responses.

It is important to modify agronomy practices to match soil type, rainfall, crop type and weed density.

Good crop competition will decrease the variability of gross margins regardless of the season.

### *Row spacing*

Row spacing has a greater effect than crop density on a crop's competitiveness with weeds. Like crop density, the effect of row spacing on yield potential is variable (Case study 3.3), though it is generally acknowledged that narrow rows are more competitive against weeds.

### *Case study 3.3 Row spacing and ryegrass*

***Table 3.1 Average yields for three row spacings for three trials at Condobolin Agricultural Research Centre.***

| | | row spacing | | |
|---|---|---|---|---|
| | | 15 cm | 25 cm | 35 cm |
| | | grain yield (t/ha) | | |
| Expt 1 | weed free | 3.2 | 2.7 | 2.7 |
| | + ryegrass | 2.6 | 2.2 | 2.2 |
| Expt 2 | weed free | 2.3 | 1.9 | 2.0 |
| | + ryegrass | 1.6 | 1.5 | 1.5 |
| Expt 3 | weed free | 1.2 | 1.3 | 1.2 |
| | + ryegrass | 0.8 | 0.7 | 1.0 |

At wide row spacings (25 and 35 cm) yields were reduced under high yielding conditions (Expt 1). Under low yielding conditions (≤1 t/ha) the wider row spacing yielded the same or better than the narrow rows (15 cm) (Exp. 3).

Weeds depressed grain yields under all conditions but did not appear to gain a competitive advantage where the wheat was sown in widely spaced rows. High seeding rates at all row spacings depressed ryegrass growth but did not give higher wheat yields.

***Source: Fettell and Bamforth, 1988.***

Narrow rows are more appropriate for cooler wetter areas where crops develop slowly. In the western drier areas narrow rows are also beneficial due to the lower yield potential and the warmer winters.

Wider rows can be used in western areas without yield penalty provided there is good weed control. As row spacing increases so can the effect of the weeds. Wider row spacing allows more space for weeds to grow and if not controlled this will result in a greater yield loss than if the crops were sown on narrow rows.

When weeds are not adequately controlled in wider rows there are increased problems with contamination at harvest and higher return of weed seed to the seed bank.

Case study 1.3 (page 8) suggests that retaining stubble will suppresses ryegrass germination between the wider rows. Other trials, however, have not yet recorded a yield increase in stubble retention large enough to compensate for the decrease in yield from the wider row spacing.

Early sowing is better for wider rows. Sowing from April to mid May allows the crop more time to develop a better canopy and root system.

In early sown crops, row spacings of up to 30 cm have shown variable yields. Late sown crops at wider row spacings had limited yield potential especially when weeds were present.

Photo: A. Johnson

***Wheat. Row spacing can determine competitiveness.***

### *Case study 3.4 Crop type and row spacing*

Research in northern NSW showed that legumes are better suited to wider rows (≥50 cm). In experiments in weed free areas, wide row spacing (64 cm) did not significantly reduce the yield of chickpea and faba bean but did reduce yields of wheat and canola.

Weeds were more competitive in chickpeas than faba beans and generally in canola, and least competitive in wheat (Table 3.2).

***Table 3.2 The yield loss at larger row spacings in northern areas.***

| | Row Spacing | | | |
|---|---|---|---|---|
| | 32 cm | 64 cm | 32 cm | 64 cm |
| | 10 weeds/m² | | 20 weeds/m² | |
| Crop | % yield loss | | | |
| Wheat | 16 | 27 | 28 | 41 |
| Chickpeas | 44 | 56 | 61 | 73 |
| Faba beans | 32 | 41 | 46 | 58 |
| Canola | 33 | 58 | 51 | 73 |

Wider rows can give better options for sowing in stubble, band or interrow spraying and fertiliser placement. Weed control is important in wider rows to minimise yield losses.

Wider rows depend more on herbicides for weed control. Other weed management strategies must be used to retain herbicide efficacy.

***Source: Felton, 2005.***

### Time of sowing

Sowing early is a form of IWM as it increases yield potential which lessens the effect weeds have on yield.

A longer growing period for the crop gives increased yield potential. At low weed densities, time of sowing determines yield more than weed competition. At high weed densities the yield increase from better weed control pre-crop needs to be greater than the yield loss from the later sowing.

*Table 3.3 Average wheat yields and date of sowing.*

| Time of sowing | Wheat yields (t/ha) | |
|---|---|---|
| | Range | Average |
| 8 May (14 slow maturing varities) | 3.91–5.58 | 4.72 |
| 30 June (26 quick maturing varities) | 2.90–3.86 | 3.33 |

Plots were sown on long fallow, rainfall was above average, nitrogen was high, weed control and harvesting were timely.

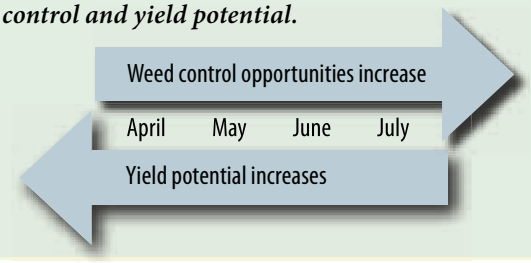
*Source: Thompson, 2002.*

### Delayed sowing and pre-crop weed control

Delaying sowing can be a form of IWM but requires careful consideration so that yields and profit are not reduced.

A majority of weeds emerge immediately after the opening rains. Delaying sowing allows time for this flush of weeds such as wild oats to emerge and be controlled at sowing with cultivation points or prior to sowing with a knockdown herbicide (Figure 3.2).

*Figure 3.2 Sowing time is a balance between weed control and yield potential.*




Cultivation prior to sowing can stimulate some weeds to germinate earlier allowing optimal sowing times for the crop.

The effectiveness of delayed sowing depends on which weeds are present and the possible volume of the seed bank. Certain weed species annually germinate less than 10% of the seed bank for that species. The majority of these do so after an initial flush of soil moisture. This is not true of all weeds. Annual ryegrass germinates up to 80% of its seedbank in the first 12 months, has a prolonged emergence pattern and provides intense competition in later sown crops.

Even if delayed sowing is not a preferred tactic, sowing at the normal time leaving the weediest paddocks last will give some opportunities to provide some knockdown control before sowing.

### Fertiliser rate and placement.

Good nutrition is needed early in the crop. Root competition for nutrients occurs early and is most important. For example, wheat effectively competes for nitrogen before the three leaf stage but ryegrass is more competitive than wheat after the three leaf stage.

Pre-sowing applied fertiliser where weeds are not controlled can promote weed growth and disadvantage the crop. High levels of nutrition can exacerbate weed competition, especially broadleaf weeds. Split applications of nitrogen (pre-sowing and topdressing at the end of tillering) give the crop the nutrition it needs to compensate for the early weed competition.

Banding fertiliser below the seed is also beneficial to the crop. The benefits of banding fertiliser close to the crop are rainfall and soil type dependant.

### Case study 3.5 – Fertiliser and row width

In the absence of weeds, crops will make the best use of all nutrients available regardless of the placement. Getting the right amount of nutrient to the crop is most important. However, in the presence of weeds, placement of fertiliser can be as important as the amount of nutrient available.

Wider rows allow fertilisers to be placed to benefit the crop over the weeds (Table 3.4). In trials fertiliser placement had a greater effect on chickpea yield than wheat yields. Fertiliser placement influences grass weeds more than broadleaf weeds.

*Table 3.4 Fertiliser placement, yield and weed response from trial in northern NSW.*

| | Fertiliser placement | | | |
|---|---|---|---|---|
| | nil fertiliser | in crop row | in weed row | ½ crop, ½ weed row |
| **Weeds** | **t/ha wheat** | | | |
| nil weeds | 2.6 | 2.9 | 2.8 | 2.8 |
| grass weeds | 2.0 | 2.6 | 2.2 | 2.7 |
| broadleaf weeds | 2.2 | 2.8 | 2.3 | 2.7 |
| **t/ha chickpea** | | | | |
| nil weeds | 1.9 | 2.4 | 2.1 | 2.5 |
| grass weeds | 1.3 | 1.7 | 1.2 | 1.5 |
| broadleaf weeds | 1.8 | 1.9 | 1.3 | 1.5 |

Crop was sown on 40 cm rows at 40 kg/ha (wheat) and 70 kg/ha (chickpea). Weeds were sown half way between the crop rows at 10 plants per $m^2$.

Getting adequate fertiliser to crops on wider row spacings requires an increased concentration of fertiliser in the row. Using higher concentrations means the seed and fertiliser needs to be carefully placed to avoid fertiliser toxicity.

*Source: Felton, 2005.*

### *Case Study 3.6 Using cover crops in the rotation for weed control. By Kathi Hertel*

| | |
|---|---|
| **Name** | Peter Knowles. |
| **Property** | "Carlile" Wellington (600 ha). |
| **Enterprise** | Cropping (wheat, barley, oats, canola, albus lupins, faba beans, field peas, chickpeas, linseed, and millet). |
| **Landscape and soil** | Undulating landscape with red clay loams to sandy clay loams to sandy loams. |
| **Rainfall** | 575 mm (non seasonal). |
| **Advantages** | "The only farming system that is sustainable into the long term."<br>Better lifestyle, timeliness of operations. Continue to improve water infiltration rates. |
| **Disadvantages** | "None yet. Herbicide resistance is only a matter of time". |
| **Future directions** | "Greater nutrient mineralisation in the future."<br>Currently using recommended planting rates, but thinking of increasing rates as ground cover levels increase. It is cost prohibitive to convert disc seeder back to 18 cm (7") row spacing, but may experiment with it in the future. |

Peter Knowles has an IWM system that includes using agronomy, crop and herbicide rotations and ground cover to maintain a sustainable farming system. In continuous cropping systems a holistic approach is important to prevent herbicide resistance. Peter is aiming for a system that minimises the reliance on herbicides for weed management.

One of the most important parts of farm management on "Carlile" is maintaining at least 80% ground cover to minimise weed germination and improve soil structure and water infiltration rates. This level of ground cover is achieved through stubble retention and cover crops in summer.

#### *Rotations*

"Nothing is fixed now." The priority is to maintain or improve ground cover. Crop choice is determined by weed spectrum and salinity risk (Figure 3.3).

Wet paddocks and those located in salinity risk areas require both summer and winter crops to maximise water utilisation.

#### *Weed spectrum observations*

Fumitory is the main problem weed species and appears to be increasing. Wild oats have been a problem, largely due to poor control over the last few difficult seasons (drought 2001–2003). Annual ryegrass is also a problem but to a lesser extent.

Another continuing problem is the small number of weed escapes in broadleaf crops. Scatterings of mustards and wireweed persist in these crops. Corn gromwell is another problem, especially in crops where no Group B residual herbicides are used.

Fleabane is problem although there are hardly any plants after a chickpea crop. Peter suspects that the residual herbicides used in chickpea also suppress fleabane germination

Photo: K. Hertel

*Peter Knowles.*

#### *Cover crops*

The use of cover crops is an important tool to delay herbicide resistance from developing. These have an added benefit of improving soil structure and mineral utilisation. Cover crops are not removing nutrients from the system but are promoting biological cycling and mineralisation of nutrients.

Cover crops reduce weed growth through competition and can be used in rotation to reduce weeds when the population is large. The use of cover crops has reduced the reliance on herbicides in crops and in fallows.

Saia oats are grown for their rapid smothering ability. The oats are laid over at milky dough growth stage with a 7.7 m homemade crimping roller.

***Figure 3.3 Rotational sequence to (a) improve ground cover or (b) control wild oats.***

(a) wheat → barley → canola → millet → wheat → barley or broadleaf (depending on salinity risk)

(b) broadleaf crop → wheat or saia oats → mung beans → canola

Millet or sorghum are grown in summer to provide ground cover and control weeds if there is minimum residue left over from the previous crop.

### Soil improvement

The system of stubble retention and the persistent ground cover has improved the soils on "Carlile". Changes to the soil include a better colour, smell, earthworm numbers, fungi and general biological activity.

### Nutrient management

Peter has a contract for cleaning out chicken sheds, that allows him use of the manure for fertiliser. Cleaning out chicken sheds takes approximately one week four times a year (Table 3.5). Manure is composted for approximately 6 months before spreading. Compost has largely replaced artificial fertilisers over the last five years. Ongoing soil tests indicate high fertility levels with no deficiencies of major or micronutrients.

Peter is aiming to have greater nutrient mineralisation in the future. He plans to further develop the current system by aiming to have an active root system for 9–10 months of the year. Cash and cover crops will be grown and the higher residue conditions will continue to decrease the reliance on herbicides for weed management.

### Cereal crop phase

In cereal crops pre-emergent herbicides Glean® or Logran B Power® (Group B) are used and give excellent early broadleaf weed control. Mataven® (Group K) is used for wild oat control either as a post-emergent or as a crop top depending on weed density.

Cereal crops with small fumitory or wireweed plants are treated with a 2,4-D amine (Group I).

### Broadleaf crop phase

Grass weeds like wild oats and annual ryegrass are controlled in broadleaf crops with selective grass herbicides (Group A) The weed spectrum also dictates the choice of product. For example annual ryegrass is controlled with dims (Group A) and wild oats are controlled with fops (Group A).

### Canola

Only conventional canola varieties have been grown to date, however triazine tolerant or Clearfield® varieties have not been ruled out. Triazine tolerant varieties would fit into a system as they could be followed by a sorghum crop to regain ground cover.

Lontrel® (Group I) is used on broadleaf weeds if control is required.

The herbicide combinaiton mostly used in linseed is a post-emergent application of bromoxynil + MCPA (Bromicide MA®) (Groups C + I) which is found to be very effective on large weeds when applied with high water rates (200 L/ha). High temperatures are thought to reduce the effectiveness of this herbicide.

In lupins and field peas, a post-sowing pre-emergent application of metribuzin (Group C) is used. Selective grass herbicides (Group A) are used as required.

Herbicides in chickpeas are usually 100 g/ha Balance® (Group F) + 1.5 L/ha simazine 500 (post-sowing pre-emergent). Selective grass herbicides (Group A) are used as required.

### Other crops

Faba beans are no longer grown as the need for frequent fungicides does not suit their management.

Safflower was trialled as a possible rotational crop to expand broadleaf crop choices. However it was decided that this was not appropriate in the rotation.

### Equipment

The disc seeder creates minimal disturbance in the rows which reduces weed germination at sowing. The disc seeder also leaves more crop residues between rows, which is thought to also inhibit weed germination.

### Herbicide management

Herbicide label recommendations are closely adhered to ensuring the best possible weed control. It is also considered very important to match application droplet sizes with the targets and conditions.

Incorporated herbicides are not used as the disc seeder gives poor incorporation.

*Table 3.5 Calender of operations on "Carlile".*

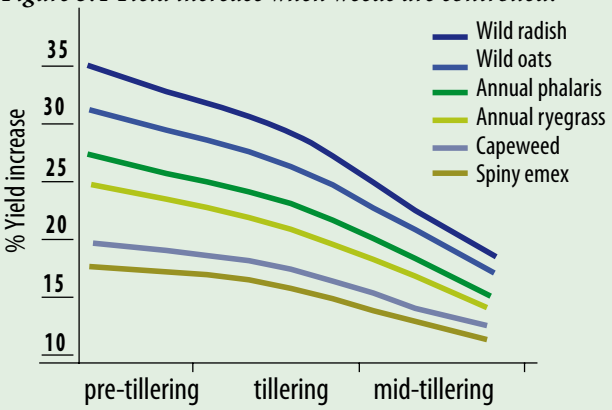
| | |
|---|---|
| **December – January** | Sow cover crop (millet or sorghum). Clean out chicken shed. |
| **January – March** | Fallow weed control. |
| **End April** | Sow canola, lupins. Let weeds germinate in other paddocks. Clean out chicken shed. |
| **May** | Sow canola, Strzelecki wheat, linseed, field pea. |
| **June / July** | Sow later wheats Ventura, Sunstate, Flipper chickpeas and barley. Clean out chicken shed. |
| **August/September/ October** | Post-emergent weed control where necessary, monitoring (and control) of insect pests. Clean out chicken shed. |
| **November** | Windrow & harvest canola. |
| **December** | Harvest. Sow cover crops. Fallow weed control where necessary |

## Management of weeds in the cropping phase

### Timing of herbicide control

Early germinating weeds reduce yield potential the most. Controlling weeds early has a greater impact on preserving yield than controlling weeds later (Figure 3.4).

*Figure 3.4 Yield increase when weeds are controlled.*




*Source: PIRSA, 1997. Data is based on 2 t/ha yield.*

The timing of post-emergent herbicide applications depends on individual products. Herbicide labels will give instructions for suitable weed size and for the best timing to minimise crop damage.

### Herbicide rates

Herbicide labels often give a range of rates. In highly competitive crops the lower herbicide label rate can be effective (Case study 3.1).

The low label rate of herbicide may be sufficient to set back the weed so that the crop has a competitive advantage. This is highly dependant on the weed type and density. There is a risk if large numbers of weeds recover from the low rate and mature and set seed.

### Other agronomy IWM

Other agronomic IWM options that need to be considered include herbicide selection and rotation, use of cultivation and farm hygiene.

Hay or silage production and green or brown manuring are other options in IWM programs if crop failure occurs or if a weed problem is out of control.

### Desiccation

Desiccation of pulse crops can help prevent seed set in ryegrass and other problem weeds. Desiccated crops ripen quickly and evenly. Desiccation in pulse crops also gives an opportunity to rotate herbicide groups. Timing of harvest can be better managed if there are many types of crops to harvest.

## Harvest

### Windrowing

Windrowing heavy crops prevents lodging. Windrows can concentrate the majority of weed seed into a small area making it easier to spray or burn.

➢ **See page 64 for burning windrows.**

### Seed capture

Some farmers are trialling the collection and retention of weed seed by the harvester where ryegrass resistance is a problem. This includes trailing bins for the capture of residue and header attachments to capture seed. This method slows down harvesting and is only economical where herbicide resistance is present.

### Seed cleaning

Seed cleaning increases the value of seed when unacceptable levels of weed seeds are present.

Using clean seed ensures that movement of weed seed to uninfested paddocks does not occur. Cleaning grain before hand feeding can also prevent the movement of weed seed. Uncleaned seed may have a minor impact on the seed bank but can have major consequences such as spreading a new weed or a herbicide resistant population across previously uninfested paddocks.

Only a small number of weed seeds are needed in a seed sample to infest a large area with a new weed.

Photo: T. McNee

*Wheat harvesting.*

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Niknam, S.R., Moerkerk, M. and Cousens, R. (2002). Weed seed contamination in cereal and pulse crops. 13th Australian Weeds Conference, pp. 59–62.


***For further information on agronomy and herbicide selection see the following books available from NSW DPI.***

**Weed Control in Winter Crops.**

**Winter Crop Sowing Guide.**

**Weed Control in Summer Crops.**

***Also see the NSW DPI and GRDC websites for the latest agronomy information.***

**www.dpi.nsw.gov.au**

**www.grdc.com.au**

Photo: K. Roberts

***Wheat grain with various contaminates.***

# Chapter 4
# Pastures

***Compiled by Annie Johnson, Nathan Border and Robert Thompson***

Photo: K. Hertel

***Sheep grazing lucerne.***

Controlling weeds in pastures improves the feed value of the pasture, increases meat and wool quality and quantity, prevents injury to stock and lengthens the life of the pasture. Weed control in the pasture phase also reduces disease and weed control costs in the following crops.

The typical mixed farming rotation in the Central West cropping zone includes two to four years of crops followed by three to ten years of pasture. This system helps control cropping weeds in the pasture phase and pasture weeds in the cropping phase. This is a low risk, low cost system.

Integrated Weed Management (IWM) for a pasture phase includes the use of –

- Pasture species selection
- Pasture competition
- Slashing, hay or silage
- Herbicides
- Quarantine

Use some form of IWM in the pasture each year. Weed control does not always directly benefit the pasture growth. However it will improve the yield potential and reduce weed control costs in the cropping phase.

### *Pastures as a part of whole farm IWM*

A three year pasture phase can reduce some crop weed populations to a point where post-emergent herbicides may not be required for the first part of the cropping phase.

A pasture phase of three years or longer has greater value than a one year pasture ley. A longer pasture phase especially in drier areas gives greater control of cropping weeds. Studies have shown that pasture and cropping phase farming can be economically similar to continuous cropping; mainly due to reduced weed control costs.

Pastures that provide consistent ground cover cause a reduction in weeds that normally germinate after cultivation or like to establish on bare ground.

For seeds stored in the soil under the pasture there is a steady reduction in the number of seeds that remain viable. This rate of decay varies depending on species, temperatures, soil type and moisture content. The combination of this process of natural decay and the prevention of seed set during the pasture phase can lead to a rapid decline of certain weed populations.

➢ **See seed bank life span for weeds in Chapter 2.**

Reducing the weed seed bank should be a key management objective for the entire pasture phase. As part of an IWM plan maximise weed control in the last year of a pasture phase and follow with a long fallow to get an effective reduction of weed seed banks before the cropping phase.

### *IWM for the pasture phase*

Weed control in pasture does not depend on herbicides. A combination of herbicide and non herbicide methods makes weed control more effective and reduces costs. Using any control method alone will not provide effective control for all weeds in the pasture.

The tools that are selected can often depend on the rainfall, time of year and farming situation. Winter cleaning is used in higher rainall areas whereas in lower rainfall areas, pastures are usually long fallowed. The choice between spray topping or spray grazing depends on the density of weeds and compared to the density of pasture plants.

Photo: J. Edwards

*Clover in flower.*

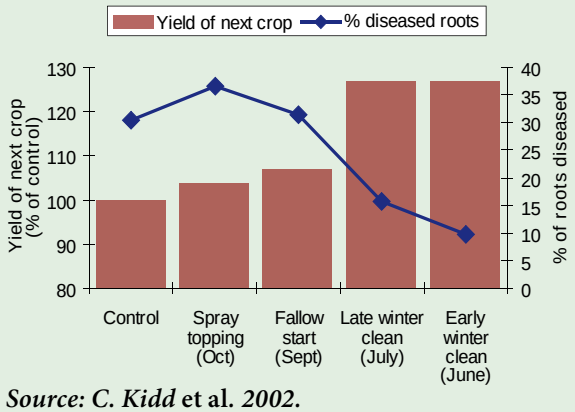
### *Case study 4.1 Grass weed control and cereal disease carryover*

Many grasses in the pasture may also carry over cereal diseases into the next crop. Herbicide control of grasses needs to be carried out early to allow sufficient time for the roots to break down and ensure there is no carryover of disease innoculum.

Research carried out in 1991–2 near Wagga, Ardlethan and Narrandera showed that ryegrass, barley grass and wild oats control in pastures increased the yield of the next crop (Figure 4.1). Winter cleaning was the most effective at reducing the incidence of take-all disease.

Other research has shown that a long fallow initiated in early winter rather than spring will also allow sufficient time for the grass residues to break down and minimise disease carryover.

***Figure 4.1 Crop yield and disease incidience in the year following grass weed control in pastures.***




***Source: C. Kidd* et al. *2002.***

### *Pasture selection*

When growing pastures in rotation with crops select a perennial based pasture whereever possible. The variation from winter crop and summer fallow to a year round pasture will limit the weed population.

Select the pasture species and varieties most appropriate to the soil type, weed spectrum and climate. A summer dominant pasture will provide competition for summer weeds such as melons or heliotrope. Clovers, medics or winter active lucerne may provide the most competition to weeds such as barley grass or capeweed.

Consider herbicide compatibility when selecting a pasture species. For example, spray topping annual grasses with glyphosate will not be an option in the first year of pasture if clover is present as this will prevent the seed set of the clover. To reduce the risk of resistance a Group A grass herbicide should only be used if one was not used in the previous year.

Seek advice from your district agronomist on the best pasture species and variety for your district.

### *Pasture competition*

Maintaining a competitive pasture with a high ground cover is important for effective weed control. Competitive pastures can be managed with good grazing and nutrition management.

Good ground cover reduces weeds such as capeweed or heliotrope that like to germinate when there is bare ground. Weeds that germinate amoungst a competitive pasture are usually small and set less seed.

Overgrazing reduces a pasture's competitiveness, allowing weeds to dominate. In a normal year, moving stock off a paddock earlier (rather than set stocking) may save on herbicide or pasture re-establishment costs. In drought years, maintaining ground cover is difficult, so budget and plan to revitalise pastures when the drought breaks to reduce the weeds dominance.

Ensuring that pastures have adequate nutrition not only allows the pastures to better compete with weeds but also increases the production and feed value of the pasture.

### *Timely grazing*

Once the pasture is established, practice timely grazing to prevent or reduce weed infestations. Control weeds by applying grazing pressure (four times the set stocking rate for 7 to 10 days) after weed germination, before they can establish. This can be for annual crop weeds in the autumn or summer weeds in late spring. Stock find fresh weed seedlings more palatable than lucerne and preferentially graze these. After this, the paddock is rested and the lucerne regrowth will use up much of the shallow moisture to prevent further germination of weeds. Where stock numbers and paddock availability is limited, target one or two paddocks a year and other options such as herbicide control in other paddocks.

Timely grazing can also be used to reduce seed set of grass weed infestations such as barley grass, wild oats or ryegrass. The timing of grazing to prevent seed set varies depending on the weed species present.

### *Slashing, hay and silage*

Mowing is an expensive weed control option in pastures in this region. It can be selectively used to control seed set in small areas or for isolated infestations of problem weeds that are about to seed. It is difficult to justify slashing pastures when there is value in conserving fodder. Hay provides income or feed during drought.

In good seasons, cutting for hay in spring may help to control problem weeds such as wild oats, ryegrass or brassica weeds, when the pasture is cut prior to maturity of the weed seed. Weeds with a short seed bank life have a high turnover of weed seeds in the seed bank. Preventing seed set for one year will reduce density of this weed in the following years.

Photo: S. Johnson

*Hay bales.*

Many annual weeds are quick maturing and may need cutting in mid-September which is a less than ideal time for making hay. A delay in cutting the hay will allow the seed to mature which then spreads to other paddocks when fed to livestock. Seek advice from your district agronomist and consider silage in these cases.

Silage involves removing all the material (including seed) from the paddock almost immediately after cutting. A well managed silage process produces heat and lactic acid to preserve the fodder and will kill up to 98% of any viable seed. Studies have found that grass seed is less likely to survive the silage process than broadleaf weeds.

### *Herbicides*

Herbicides may be necessary at some stage in the pasture phase. Good weed control in the last crop before the pasture will improve its establishment. Pasture seedlings are vulnerable to competition, especially from annual grasses. The use of knockdown and/or pre-emergent residual herbicides prior to sowing pastures is encouraged. Residual herbicides such as trifluralin and triallate can be used in most winter crops with under sown legume pasture.

There are an increasing range of herbicide for post-emergent weed problems. Established pasture (depending on the species) is tolerant to a range of herbicides. There are also various herbicides formulations used in pastures. Seek advice and check the label for rates and use of spray additives.

In lucerne, diuron, simazine or atrazine (Group C) may be used in conjuection with knockdown products such as Spray.Seed® or paraquat (Group L) to give residual control of grass weeds and problem annual broadleaf weeds (e.g. spiny emex, soursob, thistles, horehound, mintweed and toadrush).

Group A selective grass herbicides can be used in medic and clover pastures to control grass weeds. Follow herbicide rotation guidelines for pastures as well as crops.

### *Spray Grazing*

Spray grazing is the use of a sub-lethal rate of herbicide to 'sweeten' the weeds making them palatable to livestock.

Only use this method when there are low levels of the weeds present and there is plenty of alternative feed available. Where there are dense weed infestations and little alternative feed use lethal rates of herbicide and do not graze until there is good feed available.

Spray grazing targets broadleaf weeds such as capeweed, thistles, Paterson's curse, mustards and wild radish. The weeds must be at the rosette stage and less then 20 cm in diameter. Withhold stock from the sprayed pasture according to the label of herbicide used. Increase stocking rates to 8 to 10 times the normal rate so that they do not selectively graze the pasture over the weeds. Grazing should continue until the weeds have been satisfactorily reduced, but not to the point where the pasture species are at risk.

There is a risk to animal health in spray grazing as the sub lethal rate of herbicide makes the plants 'sweeter' for the livestock and encourages them to consume more of plants and consequently more of any toxic compounds in the plants. Plants such as Paterson's curse are known to cause liver damage and thistles are known to cause nitrate poisoning. This can be fatal if consumed in large amounts.

An increased quantity of poisonous plants may be eaten by the stock used in the spray graze technique and deaths may result from causes such as nitrate poisoning. Avoid grazing hungry stock and monitor stock if weeds likely to cause poisoning are present. For Paterson's curse, preferably graze stock that are destined for slaughter, do not use stock that have been previously used for spray grazing as these plants have a cumulative effect. Avoid extended periods of spray grazing. Avoid grazing with young or breeding stock and do not graze horses on Paterson's curse.

Seek advice from your district agronomist or Rural Lands Protection Board vet before considering this option.

### *Spray topping*

Spray topping reduces the seed set of weeds, particularly annual grasses and some broadleaf weeds (e.g. saffron thistles) in pasture. Spray topping of pastures involves using low rates of paraquat or glyphosate when weeds are quite susceptible at the early flowering stage before seeds can mature.

Spray topping can be used for a purpose (e.g. to reduce barley grass in paddocks used for weaning lambs next spring), or to prevent seed set of grasses missed during winter cleaning.

Some products recommend follow up control after spray topping such as grazing or reapplication if a wet spring promotes new grass growth.

Spray topping can also be used in the year prior to long fallowing to further reduce levels of grass weeds in the cropping phase. Spray topping can increase take-all innoculum in the short term (Figure 4.1). A fallow allows time for plant residues to break down which improves the disease break.

### *Winter Cleaning*

Winter cleaning is the control of some seedling weeds in pasture using selective herbicides. Winter cleaning is only suitable if there are adequate pasture plants present to fill the gaps. Otherwise a long fallow should be considered.

The herbicides commonly used in winter cleaning include paraquat (Group L) to control annual ryegrass, barley grass and some broadleaf weeds and simazine (Group C) to control vulpia.

Photo: A. Johnson

*Sheep grazing pasture.*

### *Vulpia control*

It is a very difficult task to physically get herbicide droplets to adhere to the small pin-like leaves of seedling vulpia plants. Therefore a root absorbed herbicide such as simazine is used for winter cleaning. Grazing is deferred until there has been a substantial fall of rain to wash the simazine into the soil, otherwise poor control results are likely. Weed death is often slow and results may take 6 to 10 weeks to become very evident.

### *Prevent new weeds*

Sow certified pasture seed with the lowest level of weed seeds. Certification is a guarantee of varietal purity and not a freedom from weeds. Check the seed label and acquire a copy of the laboratory report, as many weeds (such as wireweed) do not require listing on the label. Some states have different legislation, and many allow seeds of undesirable weeds like wild radish and charlock to be sold in pasture seed.

Quarantine new stock or stock that are moving from an infested to an uninfested paddock. Hold the stock for few days in a small area where any weeds that later germinate can be readily seen and controlled before setting seed. This is also recommended for feeding hay or grain that may contain weeds not already found on farm. While this may be time consuming and difficult it can save many years of problems.

If you see a new weed, identify it as soon as possible.

### *Renovation with grazing oats*

If a pasture is degraded or decimated by drought and is to be shortly returned to cropping, then herbicide control of weeds in the pasture may not be cost effective due to low pasture productivity potential.

One low cost option is to sow grazing oats at 100 kg/ha into the pasture in autumn. The pasture plants may be slightly damaged by the sowing operation, but the oats grow thickly and out-competes most winter growing weeds that are stimulated by the tillage machinery. The pasture can be intensely grazed or cut for hay in winter before being fallowed.

### *Case study 4.2 Weed seed survival in grazing stock*

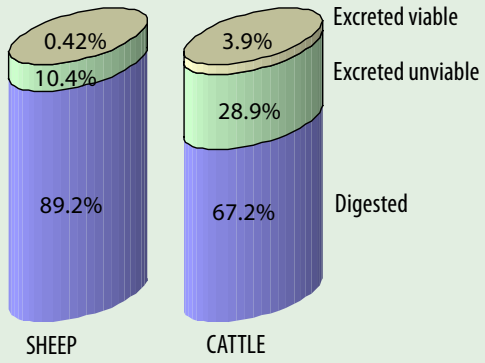
Research shows that annual ryegrass seed may be still viable after passing through sheep and cattle. The amount of seed that is still viable is only small compared to the total amount of seed excreted (Figure 4.2) and is not significant if a weed is already widespread.

Annual ryegrass can produce 20 000 seeds/m$^2$. If stock were allowed to graze in a paddock where a herbicide resistant population was present then moved to a 'clean' paddock, the number of seeds that survive would be enough to spread herbicide resistance.

There needs to be a period of up to five days following consumption of annual ryegrass seed to ensure the digestive tract is clear.

Survival of ingested seed is species dependent and thought to be much higher for broadleaf species than grass weeds.

*Figure 4.2 Outcome of annual ryegrass seed consumed by stock*




*Source: Stanton* et al. *2002*

Photo: A. Johnson

*Cattle grazing oats.*

## *Case Study 4.3 Managing competitive pastures By Karen Roberts and Annie Johnson*

| | |
|---|---|
| **Name** | Chris and Nerali Cole. |
| **Property** | "Kulgarnie" Parkes 640 ha (17 ha around creek permanently fenced off). |
| **Enterprise** | Sheep, cattle and cropping (approx. 290 ha cropping each year). |
| **Landscape and soil** | Gently sloping with red brown earths. |
| **Rainfall** | 490 mm. |
| **Advantages** | Stocking rate increased under lucerne pastures.<br>Grow competitive crops and pastures to minimise the need for herbicides.<br>Manage crop weeds in pasture and pasture weeds in crop.<br>Maintain pasture cover to control skeleton weed and saffron thistle. |
| **Disadvantages** | Capeweed and barley grass are now the biggest problems.<br>Spraying is still required. |
| **Future directions** | Considering changing paddock sizes for more flexible grazing.<br>Local catchment management plans to include weed control. |

Chris and Nerali Cole aim to only use herbicides as a last resort. They prefer to manage their weeds by maintaining competitive crops and pastures and by utilising rotational grazing techniques.

### *Skeleton weed and lucerne*

Chris and Nerali bought the property in 1984. At that time most paddocks were thick with skeleton weed despite the use of 2,4-D for many years. Pastures were not improved and consisted of 'whatever came up'. The district agronomist suggested that they plant lucerne to combat skeleton weed.

Skeleton weed does not compete well against species that form a dense sward such as lucerne. The lucerne reduced the skeleton weed to manageable levels, although it was ten years before the weed was considered under control. Now skeleton weed is rarely seen. The Coles suspect that if the lucerne phase was removed from rotations the skeleton weed would return.

Lucerne has been successful in removing the skeleton weed and other problem weeds such as saffron thistle. The pastures have been managed to maintain ground cover whenever possible. This results in little opportunity for weeds to establish.

The stocking rate of the farm has increased under the lucerne pastures. The soils are believed to be more fertile after each lucerne phase.

The local Landcare group has also discovered the benefits of lucerne. Lucerne was planted in low wet areas and on the slopes above several years ago. These low areas have now dried up and are no longer a salinity risk.

Photo: A. Johnson

*Nerali and Chris Cole.*

### *Current situation*

Barley grass and capeweed are now the biggest problems. Weeds in general on the farm are managed as part of a holistic system. Cropping cleans up the pasture weeds as much as pasture cleans up the cropping weeds.

### *Cropping*

The cropping sequence is usually wheat, barley then barley under sown with lucerne (Figure 4.3). Oats are grown for feed and hay if needed. The soil nitrogen is high after the lucerne so wheat is sown first in the rotation. Barley grain is used for feed on farm and is a good competitor of weeds. Barley is used as a cover crop as it matures earlier than wheat allowing the under sown lucerne an earlier start.

Preventing seed set in crops reduces the weed seed bank and hence the number of weeds in the lucerne phase.

*Figure 4.3 Rotational sequence*

wheat ➔ barley ➔ barley undersown with lucerne ➔ four years lucerne.

Three years of cropping are needed to reduce the soil seed bank to a point where the first year of lucerne is relatively weed free. Experience has shown that only two years of cropping results in a very weedy lucerne stand.

Sowing is delayed slightly after rainfall to allow the grass weeds to germinate. Glyphosate is used to knockdown these weeds prior to sowing. Triflur X® is used as a residual prior to sowing to control annual grass weeds in crop. Spraying in crop is generally avoided. This is possible as there is not a large wild oat population.

### *Managing the pastures*

Lucerne requires careful management. The lucerne rotation is generally about four years. A range of well suited lucerne varieties are used so that if there are any problems with a particular variety not all production is lost. If weeds begin to establish in gaps in the pasture then the lucerne is removed and the paddock is fallowed for cropping.

Stock are moved often as they can rapidly eat the lucerne off when it is growing well. The lucerne recovers faster when it is not eaten back to bare stems. Stock are removed early and hand fed when it starts to get dry. Supplementary feed such as oat hay or barley grain are always produced and stored on farm. If the dry period is short the pastures recover quickly and stock can be returned. If the dry period is long the remaining ground cover protects the soil from erosion.

Weeds in pasture are prevented from setting seed whenever possible. If capeweed or barley grass are a problem, the pasture is spray topped with a low rate of glyphosate at the time of barley grass and capeweed flowering to prevent seed set. This timing coincides with clover flowering which is why the Coles feel it is not a suitable species to fit in their system. Higher glyphosate rates are used the year before returning to cropping.

Annual ryegrass occurs in the lucerne however this is not considered a pest as the sheep and cattle graze it freely and control seed set. If seed set is controlled over the lucerne phase the weeds are not a problem in the cropping phase.

Wild radish is a problem in one paddock on the property since being sown with contaminated lucerne seed three years ago. The paddock has been treated and the wild radish is closely monitored.

### *Fallow*

Heliotrope likes to establish on bare ground and can be a problem in fallows. Lucerne pastures keep heliotrope populations under control in the pasture phase. Timing of cultivation is important when controlling heliotrope. Cultivating the fallows around Christmas has been successful in controlling most of the heliotrope in the fallows but if the paddock is cultivated pre-summer or late summer, heliotrope will survive.

### *Waterways*

The creek and waterways are fenced off from stock. Slashing has been considered very successful in these areas and the native species have started to return to these areas and outcompete weed species.

### *Future directions*

The Coles consider spraying wasted money and are always looking for alternatives to manage weeds. The CattleCare and ProGraze programs influence many of their decisions. These programs have helped them to learn a lot about grazing management. Future changes may include reducing paddock sizes for more flexible grazing management. The ideal size is yet to be decided "but could be around 50 acres".

The farm will continue to be managed as a whole system. The cropping supports the pasture system and *vice versa*. The farming system supports the environment; for example, the waterways and the native vegetation.

The local Landcare group is involved in developing a Catchment Management Plan with Ryde TAFE students. This plan will include weed control issues. The Coles will be involved in the process of implementing this plan once it is developed.

Photo: A. Johnson

*Barley crop on 'Kulgarnie'.*

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Various pastures information, species and management www.dpi.nsw.gov.au/reader/pastures

***For further information on Pasture Management see the following books available from NSW DPI.***

**Weed Control in Lucerne and Pastures.**

**Fertilisers for pastures.**

**Pasture Managment for Weed Control:**
**A grazier's guide to controlling annual weeds in southern Australian improved pastures.**

Photo: J. Edwards

***Lucerne in flower.***