NSW DPI

# WEED CONTROL

## FOR CROPPING AND PASTURES IN CENTRAL WEST NSW

Compiled by Annie Johnson

GRDC Grains Research & Development Corporation

NSW DEPARTMENT OF PRIMARY INDUSTRIES

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- NSW DPI Bookshop on 1800 028 374 or
- your district agronomist at local NSW DPI offices.

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GRDC
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# Introduction

# Integrated Weed Management

*by Annie Johnson*

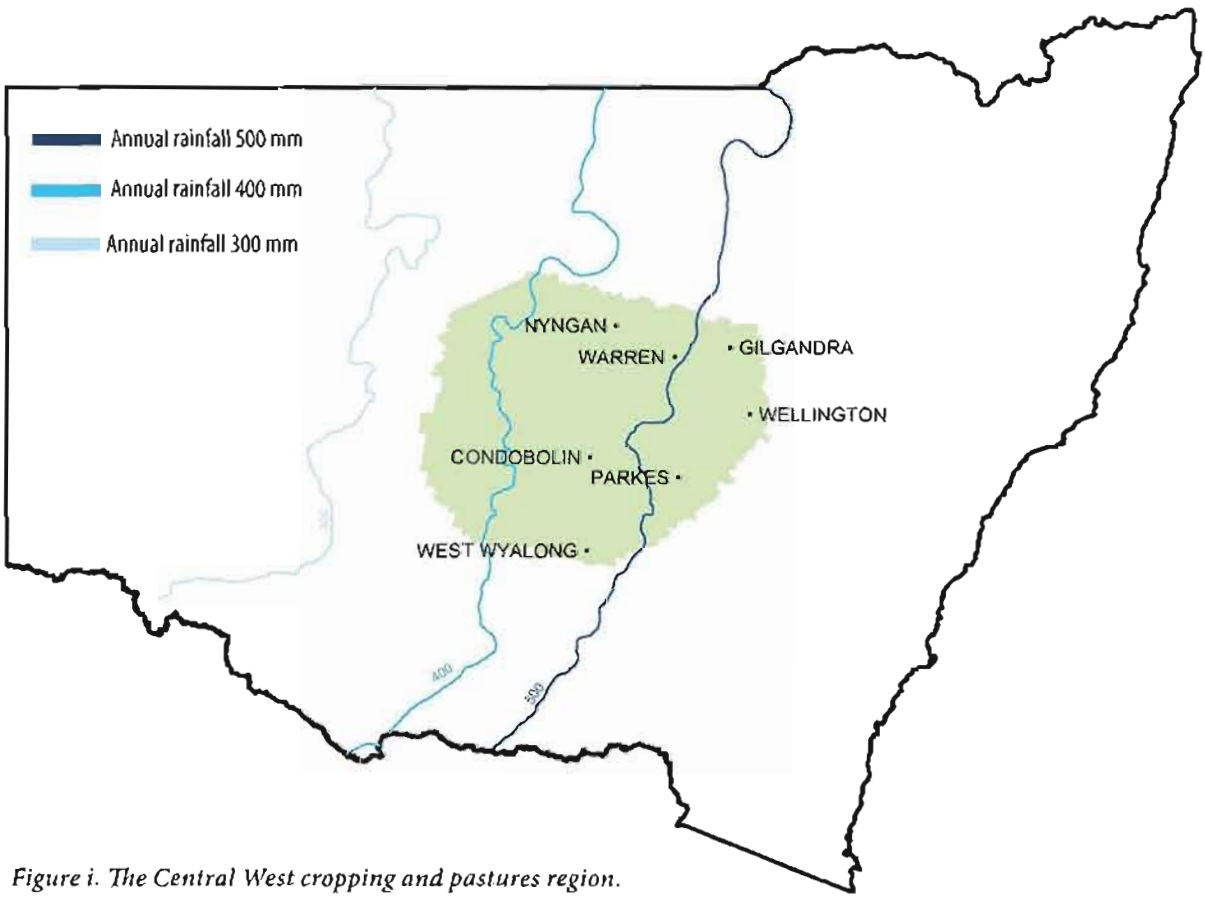



*Figure i. The Central West cropping and pastures region.*

### *The Central West*

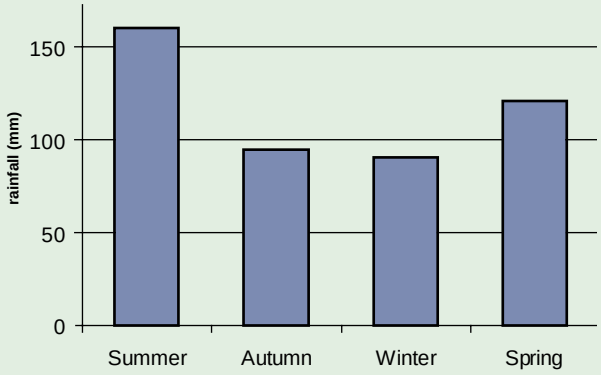
This book was written to provide information on the current best practice weed management for the Central West cropping and pastures region. It contains information that is specific for this area's climate, cropping and weed spectrum. Previously, weed management information focused on the northern or southern Australian cropping areas.

The Central West cropping and pastures region is mostly defined in this book as the area between the 350 mm and 550 mm annual rainfall zones (Figure i) from West Wylong in the south to Gilgandra in the north.

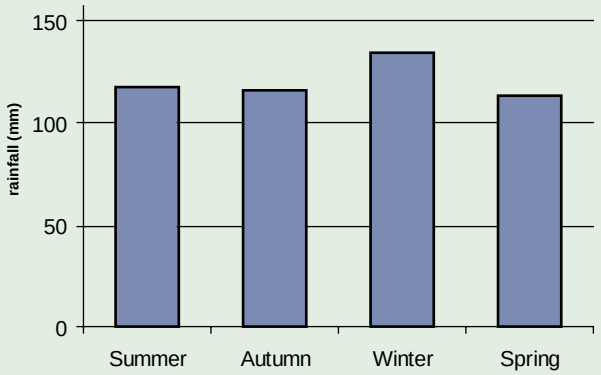
This area is unique in its farming systems and weed spectrum due to its location between the northern subtropical summer rainfall zone and the winter dominant rainfall zone of the south (Figure ii).

***Figure ii. Rainfall patterns for a northern summer dominant (a), non-seasonal (b) and winter dominant (c) rainfall zones.***

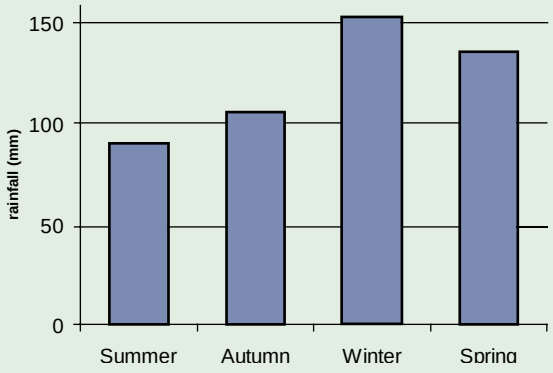
***(a) Moree median rainfall***




***(b) Parkes median rainfall***



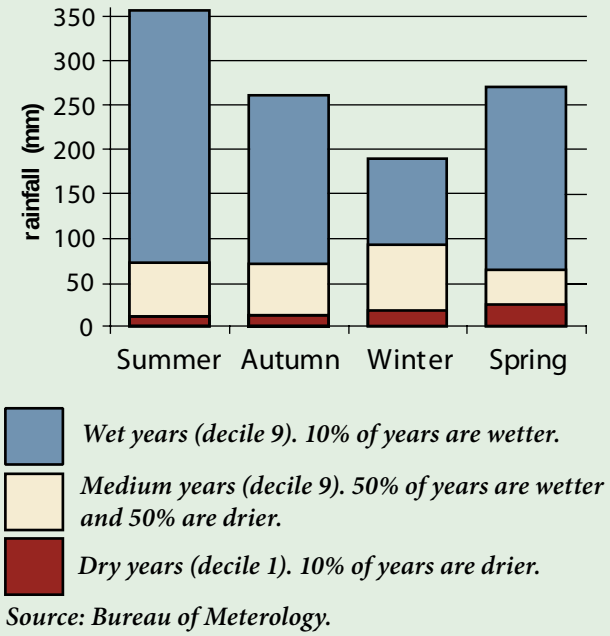

***(c) Wagga Wagga median rainfall***




Rainfall in the Central West is generally non-seasonal. Wet years are more likely to have spring and summer storms with large falls of rain, but in drier years winter and spring months to receive greater rainfall (Figure iii).

The weeds that occur in the Central West are a mix of summer and winter growing weeds. Some problem weeds are specific to crops or pastures, others are a problem in all parts of the rotation.

***Figure iii. Condobolin medium rainfall.***




***Source: Bureau of Meterology.***

The Central West has seen a large shift in land use since the 1980's. These shifts include the increased use of reduced tillage and stubble retention systems, a broader range of crop and pasture species grown, as well as changes in livestock production.

These changes in land use have resulted in changes in weed spectrum on many farms in the Central West. Herbicide resistance in weeds such as annual ryegrass and wild oats has also emerged in some locations.

### *Integrated Weed Management*

Integrated Weed Management is the planned and managed use of physical, chemical and biological measures to control specific weeds or weed populations (Table i). IWM involves using many pre-emptive strategies as well as direct weed control tools.

IWM can reduce the reliance on herbicides for weed control which in turn reduces the risk of herbicide resistance developing.

There are a whole range of IWM tools. Farmers need to develop weed management plans and select the tools that are best for each individual situation and weed spectrum. It is not necessary to use every IWM tool, however, using a wide variety of tools reduces risk.

IWM tools do not always directly control weeds but are effective for weed management. For example, fertilisers can increase crop and pasture production, make the crop and pasture plants more competitive against the weeds and reduce the dependence on herbicides to maintain production. Integrating other farm management tools into the IWM plan will allow these tools to be used in a timely manner which will contribute towards improved weed control.

Successful IWM strategies utilise herbicides and a range of non-chemical control methods which suit the farming system. The challenge in managing weeds is to understand the key aspects of the biology, ecology and population dynamics of a weed and to exploit those characteristics with appropriate tools.

### Planning

Weed control is a significant farming expense. IWM sometimes involves making choices that may not always be the most economic in the short term but give the greatest return in the long term.

It can be difficult to determine what is the best choice during busy times. Planning is crucial so the right choices are made for the long term management of weeds. Decisions that are just quick fixes for problems might not always be the cheapest in the long term.

Farmers know and use most IWM tools separately. However, a farmer survey of the Central West in 2002 found that most farmers did not have a plan for weed control. Without a plan, IWM tools are not always used to gain the best effect.

Important factors that assist with planning include farm observations, correct weed identification and record keeping. Plans also need to include thresholds and timing for weed management.

### Observations

A very important part of IWM is to observe what weeds are growing on your farm. Monitoring weeds can help determine how management affects the weeds population. Monitoring means a new weed can be detected early and eradicated before it gains a foothold across the farm.

Encourage everyone on farm, family or workers to keep an eye out for weeds and to report anything that may be different or unusual.

### Identification

Correct identification is essential for good IWM planning. If you do not know the identity of a weed, ask your district agronomist.

### Records

Keep good records, not only of herbicide use (a legal requirement), but also of weed species, numbers present, and other farm operations that affect weed management (cultivation, grazing times). These records play an essential part of planning future IWM. Records allow predictions to be made on weed response to management.

### Thresholds

Thresholds determine when certain management options can be utilised. Thresholds are not only determined by the level of weeds present but also by the current and future uses for that paddock. For example, a pulse crop requires a very low level of weeds while a cereal crop is much more competitive and can tolerate higher levels of weeds.

Thresholds can be used to determine the best way to use resources without overspending. For example, it may not be economical to winter clean every pasture paddock every year. However, if weaning lambs, cleaner paddocks are required. In the previous winter, the thresholds would be lower in the paddocks planned for the lambs and spraying may take place.

### Timing

The timing of farm management operations plays an important role in IWM. The agronomy chapter discusses timing and rate of sowing and fertiliser application(s) and the timing of direct weed control.

Research on fallow weed control and yields found that the greatest influence on grain yield was controlling weeds before they used soil moisture not whether they were controlled by herbicide or cultivation.

*Table i. Integrated Weed Management tools and where they are found in this book.*

| IWM tools | includes | Chapter |
|---|---|---|
| Planning | rotations, use patterns, | 1 |
| | species biology and ecology | 2 |
| Physical | agronomy (competitive crops and pastures, sowing time and rate, fertiliser, stubble management, hay and silage production) | 3, 4 |
| | grazing (use and timing, rest periods) | 4 |
| | cultivation (use and timing) | 5 |
| Chemical | rotations, use patterns | 1 |
| | spot spraying, spray topping | 4 |
| | resistance management | 7 |
| | product selection, wetters, water volume, timeliness, use patterns | 8 |
| Biological | introducing agents, maintaining refuges. | 6 |

### *Herbicides*

Herbicides must be considered as just one component of an overall integrated system together with cultural control and other management strategies.

If herbicide resistance occurs, management of the population of resistant weeds cannot be achieved by simply changing the herbicide mode of action. When herbicide resistant populations of annual ryegrass were treated with other herbicide modes of action in Western Australia, multiple resistance emerged.

This shows that an integrated approach to weed management that uses many tools not just herbicides is very important to maintain the effectiveness of the herbicides.

### *Quarantine*

Preventative management is often the most cost effective weed control. Observations play a key role in preventing new weeds from establishing on farm. Preventative management is not just important for new weeds but also to prevent a population of herbicide resistant weeds from being brought on to the farm.

If only small areas of a weed exist, spot spray or chip the area. Although costly in terms of time, this is very cheap compared to a lifetime of chemical use if that weed spreads.

Observe at-risk areas, for example where hay is fed out during drought. Simple follow up can then prevent new weeds from establishing.

Wash down machinery before moving it from an infested area to an uninfested area. Contract machinery should be cleaned before leaving the previous farm. Monitor wash down areas for new weeds.

Buy certified seed and check the laboratory report as some weeds from interstate are not required to be on the label if they are common in that state.

### *Noxious weeds*

Some of the weeds mentioned in this book may be declared noxious under the ***Noxious Weeds Act 1993.*** This may result in mandatory management of these weeds in some areas.

Further details can be obtained from your local council weeds officer or district agronomist.

Photo: J. Edwards

***Paterson's curse (left) and canola crop (right).***

# Chapter 1
# Rotations

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

Photo: J. Edwards

***Wheat and canola crops.***

Rotations are a critical part of Integrated Weed Management (IWM). Rotations allow alternate weed control methods to be utilised which reduce weed burdens, weed control costs and the risk of herbicide resistance developing.

Rotations are not only important for weed control but also provide a disease break, a source of soil nutrition and help to spread the economic risk.

Planning an IWM rotation does not just involve deciding which crops will be grown. It also involves planning which herbicide modes of action will be used and when and where a double knock, cultivation, green manure crop, pasture or hay production could be used.

This chapter outlines these choices as well as some possible scenarios with farmer case studies.

### *Planning rotations*

When planning a paddock rotation many factors influence the decision. Market prices, sowing windows, soil type, moisture availability and the likely weed spectrum (from paddock records) are all important.

Crop selection should consider controlling weeds that are easy to control in that crop. For example cereal crops to control broadleaf weeds and broadleaf crops to control grass weeds.

Avoid planting crops where there are minimal herbicide options for controlling the weeds present. Weed species and available in crop controls are often forgotten and some managers find themselves with weeds that are uncontrollable in that crop.

### *Drought*

Drought conditions can play havoc with crop rotations and weed control. Low expected returns and often unsuitable conditions for weed control mean that opportunities for managing weeds in crops and pastures is particularly difficult. Weed seed set is often left unchecked in drought years.

In drought plants are frequently under stress and when weeds are stressed herbicides are less effective. Crop damage from herbicides is more likely when the crop is stressed.

In pastures, overgrazing and drought leave bare ground creating ideal conditions for weeds to germinate when rain arrives. Unpalatable broadleaf weeds such as Paterson's curse, capeweed and thistles often dominate for several seasons afterwards. Where there is a lack of weed control in winter/spring and low competition from pastures in autumn, weeds such as barley grass and brome grass can become very prevalent. In western areas, weeds such as galvanised burr, yellow burr daisy, spiny emex, spiny burrgrass and thistles can be problems for years after drought.

In severe droughts, recruitment of weeds and a lack of ground cover after the drought are more of a problem than weed growth and seed set during the drought.

After drought the lingering effects of residual herbicides should be assessed before planting the next crop or pasture. Herbicides break down very slowly in dry soil. The plant-back period for some herbicides only starts after significant falls of rain, so plant back periods after drought are usually extended.

For many managers, rotations often fall by the way side during drought, with little opportunity for paddock preparation and delayed sowings.

Where a crop was planted and failed, it is best to move onto the next crop in the rotation, rather than sow back–to–back crops of the same type. This is especially important with broadleaf crops.

Photo: A. Johnson

*Field pea in flower.*

Photo: J. Edwards

*Canola flower.*

➢ **See chapter 8 Herbicide Use on pages 81–89.**

### *Herbicides*

When planning a rotation, consider which herbicides to use. There are many herbicides available for in–crop weed control (Table 1.1). These range from the Group A selective grass herbicides (highest herbicide resistance risk) through to the Group L and M non–selective herbicides (least herbicide resistance risk).

Multiple applications of herbicides with the same mode of action over a number of years will lead to resistance. For example, in a rotation of wheat / canola / barley it is possible to use trifluralin (Group D) as a pre-emergent under all of these crops. This is not recommended as it increases the risk of developing a population of Group D resistant weeds, even if other modes of action are used during the year.

Always consider the next crop in the rotation. Some pulses are extremely sensitive to some of the Group B herbicides. Residual herbicides such as Group B sulfonylurea's (e.g. Logran®, Glean® or Ally®) break down slowly in the soil under low rainfall and high pH conditions and have been known to cause damage to the following year's crop.

Planning the weed control for the rotation is very important. Ensure that before planting a crop there are adequate herbicides available to control the weeds that are likely to grow in that paddock.

Avoid growing pulses in paddocks where herbicide options are limited or non existent to control the weeds present. Examples include spiny emex, sowthistle and saffron thistle in lupin crops.

For information on which herbicides to use in each rotation crop, see the "Weed Control in Winter Crops", "Weed Control in Summer Crops", or "Weed Control in Lucerne and Pastures" handbooks available from NSW DPI.

### *Pastures*

A well managed pasture phase can increase crop yields, delay herbicide resistance and reduce weed control costs.

Without active weed control during the pasture phase herbicide resistance is still a real risk. A pasture that is treated as a 'minimum management' phase will only become a weed increase phase which will increase the risk of herbicide resistance developing.

A pasture that is part of an IWM rotation needs to be well established with suitable varieties and provided with adequate nutrition. Weed control during the pasture phase can involve herbicide and non-herbicide methods, e.g. hay, silage and grazing (Table 1.1).

➢ **See chapter 4 Pastures on pages 52–59.**

*Table 1.1 Herbicide mode of action options. NB: Critical comments apply. Always read the label.*

| Crop type | Herbicide mode of actions | | | | | | Suitable for windrowing |
|---|---|---|---|---|---|---|---|
| | Pre-emergent | Post-emergent | Late control (wild radish) | Spray topping (ryegrass) ** | Pre-harvest | Crop Dessication | |
| Wheat | B, D, E, G+B | A, B, C, I, G+I, F+I, K | B* | | I, L, M*** | | |
| Barley | D, E | A, B, C, I, G+I, F+I | B* | | I | | |
| Oats | | B, C, I, F, G | B* | | I | | |
| Conventional Canola | D, E, K | A, I | | | | L | Yes |
| Triazine-Tolerant Canola | C, D, E, K | A, C, I | | | | L | Yes |
| Clearfield® Canola | D, E, K | A, B, | | | | L | Yes |
| Chickpeas | C, D, E, F | A B | | L | | M or M + B | |
| Field Peas | B, C, D, E | A, B, C, I, F | | L, M | | M | Sometimes |
| Faba Beans | C, D, E, B | A | | L, M | | M | |
| Lupins | C, D, E | A, B, F | | L | | | Yes |
| Lentils | C, D | A, B, F | | L | | M | |
| Fallow | B, C, I, L, M | | | | | | |
| Brown manure crops | L, M | | | | | | |

* Broadstrike® only
**Spray topping with paraquat needs to be done after crop is physiologically mature and to sterilise seedset in annual ryegrass. See label for instructions.
*** After grain < 28% moisture.

| Pasture type | Control options | | |
|---|---|---|---|
| | Pre-emergent | In crop | Non herbicide |
| Lucerne | D | A, B, C, I, F +C, J, L | Grazing, Hay, Silage, Slashing |
| Medics | D | A, B, D, I, L | Grazing, Hay, Silage |
| Clovers | D | A, B, C, C+I, F+C, F+I, I, L | Grazing, Hay, Silage |
| Grasses | A, B, C, C+I, I, J, L | | Grazing |

➢ **See page 12 for example rotations.**

### *Case Study 1.1 Weed control through rotations 1. by Kathi Hertel*

| | |
|---|---|
| **Name** | James Hassall. |
| **Property** | 'Kiewa' Gilgandra (1690 ha). |
| **Enterprise** | Cropping (wheat, triticale, canola, albus lupins, faba beans and chickpeas) and prime lambs. |
| **Landscape and soil** | Mostly flat with some gently undulating landscape, with predominately clay to silty loams and some sandy shallow soils. |
| **Rainfall** | 570 mm (non seasonal) |
| **Advantages** | Efficient operation. The man hours needed are reduced. |
| | Only small capital needs. e.g. – 150HP tractor, Hardi boomspray and airseeder. |
| **Disadvantages** | Need to make decisions at short notice at times when weather and weeds (and pests) dictate action to ensure effective control. |
| **Future directions** | System continues to evolve. |
| | Improved sustainability in the long term with no herbicide resistance problems. |

#### *Crop rotation*

The main priorities for the cropping phase are to "promote soil health, limit soil-borne disease and avoid herbicide resistance through active crop and chemical rotations".

The majority of the better quality country on 'Kiewa' is continuously cropped (Figure 1.1). The area that includes the prime lamb enterprise includes a three year lucerne phase in the rotation. The lighter sandy soils are currently managed with a triticale / lupin rotation although in the future is expanded to include other dual purpose cereals and field peas.

*Figure 1.1 Rotational sequence for (a) continuous cropping and (b) mixed cropping enterprise.*

(a) canola → wheat → pulse →wheat → canola → wheat → pulse etc.

(b) canola → dual-purpose wheat → pulse → dual-purpose wheat → canola → wheat undersown with lucerne → lucerne (3–4 years) → canola

Pulse crops are looked at in relation to their benefits to the whole system in terms of rotating herbicide groups and boosting soil nitrogen despite their often lower returns in the year they are grown. "Each paddock is not looked at in isolation as benefits flow on for two to three years."

"When deciding on what crop to put in a paddock, our first priority is to stick to our rotation. Within that, the decision of whether to sow early (long-season wheat, faba beans) or later (short-season wheat, chickpeas) is strongly influenced by our chemical group rotation requirements" (Table 1.7).

Photo: K. Hertel

*James and Emilie Hassall.*

#### *Weed management*

"We have all the usual weeds; ryegrass, wild oats, barley grass, phalaris, shepherd's purse, saffron thistle, amsinckia, milk thistle, wireweed and capeweed are probably the main ones. The usual summer fallow weeds are caltrop, melons, heliotrope and summer grasses."

"Our aim for a long time now has been to keep weed seed banks to a practical minimum through effective in crop and fallow weed control and herbicide mode of action rotation. Our goal has been to reduce the chance of significant weed burdens in crops where there are limited, expensive or no control options."

Weeds that are not kept in check can be very expensive both in terms of control costs and subsequent crop performance losses. Therefore the emphasis is on good broadleaf weed control in cereals and good grass weed control in canola and pulses.

*Table 1.2 Calender of operations on 'Kiewa'.*

| | |
|---|---|
| January – March | Fallow management as required. |
| Early April | Sow dual pupose wheat (Wylah). |
| End April – early May | Sow faba beans and albus lupins. |
| May | Sow canola (1–15 May). Sow Sunvale & Strzelecki wheat. Sow triticale. |
| June | Sow later wheats. Sunvale (on colder country), Bowerbird, Jimbour chickpeas. |
| July | Monitor weed populations and control as required. Apply mancozeb to chickpeas and On-Duty® to canola. |
| August | Monitor weed populations, and control as required. Broadleaf weed control in lucerne if required. |
| September | Late crop top application of Mataven® if necessary. Apply mancozeb to chickpeas and faba beans. Lucerne sprayed for removal and barley grass and ryegrass in lucerne spray topped. |
| October | Monitoring (and control) of insect pests. |
| November | Windrow and harvest canola. |
| December | General harvest. Dessicate and harvest chickpeas. Fallow weed control where necessary. |

"We realise that being solely reliant on herbicides for weed control can lead to plants becoming resistant to particular herbicides if we fail to actively rotate our chemical groups. We rely heavily on our consultant agronomists, IMAG Consulting in our case, to monitor weed burdens, plan appropriate chemical rotations and most importantly, make objective chemical recommendations".

"To date we have not noticed any significant changes in the weed spectrum across the board, however some paddocks have seen an increase in certain weeds such as marshmallow and silvergrass. Specific control strategies will be introduced to rectify this. As expected, the season has the largest bearing on the weed spectrum for any particular year, but overall I feel that our weed burdens have been decreasing over time".

### *Agronomy*

Canola and pulses are sown between the standing wheat stubble rows. This prevents crops being smothered by stubble and stops dirt from being thrown across into neighbouring furrows at sowing.

If there is an early seasonal break, sowing is delayed to allow time for weeds to germinate, which are then sprayed out with glyphosate before sowing starts. This allows the crop a "good clean start".

Paddocks sown at the end of May to chickpeas or late wheat are sprayed with Roundup® CT in the second half of April. These paddocks are then sprayed with Spray. Seed® prior to sowing in early June (Table 1.7). The result is that weeds are small and only require a lower rate of Spray.Seed® with the added benefit of rotating to another mode of action (particular for the grass weeds).

➢ **See pages 12 for herbicide rotation on 'Kiewa'.**

### *Wheat*

The wheat crop is sown into the same furrow as the preceeding pulse or canola crop (still between the wheat rows of two years ago). This reduces the incidence of crown rot infection and allows wheat roots to follow soil pores left by the canola or pulse roots.

Glean® or Ally® (Group B) and MCPA LVE or 2,4-D amine (Group I) are used in rotation according to weed pressure and with the view of maximising chemical rotations.

Wild oat populations in wheat are carefully monitored. Light infestations, escapes or late germinations of wild oats in wheat will be controlled by Mataven® (Group K) instead of a selective grass (Group A) product.

### *Fallows*

Maintaining standing stubble on fallows reduces the air flow across soil reducing evaporation and the spread of disease. Sowing between the standing stubble also helps stubble flow through the seeder.

Stock are not generally used to control weeds in fallow. Weeds are generally controlled using 1.0–1.5 L/ha Roundup® CT (Group M) and up to 1 L/ha Surpass® (Group I) (optional depending on weed spectrum and size). Occasionally Garlon® (50 mL/ha) (Group I) is added if melons are present. Fallow sprays are timed to occur seven to ten days after rain.

### *Canola*

Clearfield® canola varieties are sown into paddocks with (Australian) bindweed or other difficult weed populations, otherwise conventional canola is grown.

Treflan® (Group D) is usually applied to rotate the mode of action used against ryegrass and wild oats. Lontrel® (Group I) for broadleaf weeds is generally not required. Selective grass weed herbicides are always applied to canola to keep seed banks to a minimum, and to avoid, if possible, their use in cereal crops.

### *Pulse Crops*

Chickpeas, faba beans and lupins receive split applications of simazine (Group C). These are applied pre-sowing and post-sowing pre-emergent. This has the effect of concentrating the band in between the rows. The simazine is also covered and protected if it doesn't rain soon after sowing. The second application controls the weeds coming up in the bands and reduces the amount of herbicide washing into the furrow and damaging the emerging crop. Again, a selective grass (Group A) herbicide is always applied.

### *Pasture*

The pasture phase is generally maintained for three to four years. Weed populations are monitored and controlled as required. The pasture phase managed to prevent an unacceptable weed seed bank buildup.

Annual ryegrass and barley grass are spray topped as required and always the year prior to when the lucerne is removed. The pasture is spray fallowed mid-late spring before weed seeding and ten days after stock have been removed. Stock are not allowed back for another week to allow sufficient time for the pasture roots to fully mobilise the chemical.

### *Paddock hygiene*

Paddock hygiene is an integral part of ongoing weed management. Where known problems exist, populations are actively managed. For example, there is no wild radish except where contaminated faba bean seed was sown in 2000. In this area, herbicides like Tigrex®, Glean® and OnDuty® (Group B) have been applied. The area was even hand weeded when sown to chickpeas to remove any escapes. These plants are taken away and burnt. The area is monitored to maintain a weed free status. As an added precaution, no seed harvested from this paddock is retained and the harvester and seeder are cleaned down thoroughly before leaving the paddock.

### *Spraying system*

Heavy standing stubble can shield small weeds from herbicides. The boomspray nozzle spacing has been set to match the seeder row spacing to give even coverage to every plant row. This spacing also allows for triple overlap of the spray pattern which means that undetected nozzle blockages at night are less of an issue.

Spraying is with a Hardi trailing spray rig fitted with Teejet® quick change nozzle bodies at 30.5 cm spacing hosting alternately three or four nozzles. The Hardi boomspray has a width of 90 feet and only has to travel on every third tramline . The nozzle configuration can be directly targeted over crop rows. Nozzle bodies have three different nozzles to suit different situations (Table 1.3).

Chickpea and faba beans are sown on every second row (60 cm row spacing) and the corresponding boomspray nozzles are fitted with a fourth nozzle with a 60˚ spray angle. This allows early fungicide sprays to be applied in a narrower band over the crop rows only. This results in significant savings in fungicide.

Nozzles and filters are checked regularly and nozzles replaced before unacceptable wear is evident, as indicated by water rates outside specifications and uneven spray patterns.

*Table 1.3 Nozzle configurations used on 'Kiewa*

| Nozzle | Use |
|---|---|
| XR Teejet 015. Ceramic flat fan. | For the majority of chemical applications with water rates of between 50 and 70 L/ha. |
| AI Teejet 02. Air induction | For situations where drift must be kept to a minimum. ie. 2,4-D applications around succeptible crops. Water rates around 60 L/ha, low pressure. |
| TJ Teejet 03. TwinJet. Stainless Steel | For fungicide and Spray.Seed® applications which require good coverage. Higher water rates of between 80 – 150 L/ha. |

Close attention is paid to decontaminating the boomspray when changing chemicals and spraying susceptible crops. Decontamination chemicals are cheap when compared to the sub-lethal damage that can occur to crops, particularly damage that is not detected.

"We plan to modify our tramline system by sowing the two tramlines not used by the boomspray. The boomspray will be fitted with a small tank, an electric pump and two hooded AI nozzles behind the wheels. These will apply a residual herbicide such as OnDuty®, Monza® or Flame® (Group B) to prevent the late weed germination which can occur in the wheel tracks due to the lack of competition from the crop."

### *Water*

All bores have been tested for water quality. Only those with better quality are used for spraying.

Water application rates are mostly 50 L/ha, however Spray.Seed® is applied at 100 L/ha, fungicides at 100–150 L/ha (depending on crop size) and grass herbicides at 70 L/ha.

Lower pressures and larger droplets are used for the low water rates to reduce drift. At the higher water rates, high pressure and smaller droplets allow better coverage essential for these products.

Photo: A. Johnson

*Field peas.*

### *Green and brown manure crops*

Green manure crops are traditionally grown and ploughed in to kill off the crop and any weeds. The use of herbicides to achieve the same result is often termed brown manuring.

Manure crops or 'sacrificial' crops are not grown for production but are used to reduce weed populations in heavily infested paddocks that are reducing crop production.

Manure crops provide competition, change the soil environment and may even release phytotoxins that prevent weed establishment. Manure crops can also benefit following crops by increasing nitrogen, improving soil structure, reducing disease and preventing erosion.

Vetch is a legume used as a winter manure crop. Vetch is green or brown manured prior to seed set of both weeds and the vetch to prevent future weed problems. Trials found that by preventing seed set of weeds, hairy vetch reduced weed density by 70–78% and weed biomass by 52–70% in the following crop compared with a fallow treatment.

### *Hay and silage*

An alternative to a green manure crop is to grow a crop or pasture for hay or silage production. Hay or silage production helps control problem weeds such as wild oats, mustard or ryegrass.

➢ **See pages 54 for more on hay and silage.**

### *Cultivation*

Reliance on rotating herbicide mode of action groups will only delay herbicide resistance not totally prevent it from occuring.

Considering cultivation as part of the rotation does not mean returning to old techniques and machinery. There are a range of specifically targeted techniques that can be used as part of the rotation once every one, two or three years, and still maintain the benefits of minimum tillage to soils and production.

Cultivation must be targeted and effective to prevent resistance. Cultivation must be timed to reduce a significant proportion of a problem weed species (i.e. the one at risk of developing resistance). Cultivation in summer will not reduce the number of winter weeds and vice versa. If cultivating to prevent resistance check the paddock regularly and prevent any survivors of the cultivation from setting seed.

Cultivation can be used to stimulate the germination of weeds prior to sowing so that they can be controlled with a knockdown herbicide (Group M/L) rather than a selective grass herbicide (Group A) in crop.

A full cut sowing operation combined with a post-sowing pre-emergent, or a residual herbicide can provide good early in crop weed control and the double knock effect of the two controls will provide effective weed control and delay resistance developing.

Photo: K. Hertel

*Field pea crop.*

### *Case study 1. 2 Stubble, Tillage and Ryegrass by Neil Fettell*

Farmers in western NSW have traditionally grown crops in rotation with a legume based pasture phase. Weeds in this system were managed by grazing, pasture topping and long fallows.

Conservation tillage systems, including stubble retention systems, have allowed an intensification of cropping with pulse crops replacing legume pastures in rotation. Continuous cropping has an increased reliance on herbicides for weed control which has a greater risk of developing herbicide resistance.

A long term trial at Condobolin Agricultural Research Centre measured ryegrass populations under continuous wheat crops with a range of stubble and tillage practices. This trial started in 1978. A selective grass herbicide (Group A) was applied to all plots most years with at least 11 applications from 1978 to 1999. Group D herbicides were applied pre-sowing in 1996 and 1998. Prior to 1993 ryegrass densities were generally low and controlled by post-emergent herbicides. In 1993 after herbicide application, small treatment differences were evident (Table 1.4). Ryegrass herbicide resistance to Group A herbicides was also suspected in the stubble mulched and stubble retention systems from 1995.

The ryegrass counts varied as the counts were sometimes taken pre-herbicide and sometimes post-herbicide application. In general, however, the ryegrass in some treatments was steadily increased.

The higher ryegrass densities in the stubble mulched compared to the stubble retained suggests that cultivation creates better conditions for ryegrass to germinate and establish than direct drilling.

In another part of the trial in a pea-wheat rotation there was almost no ryegrass in the traditional tillage system. In the stubble mulched and stubble rentention systems the ryegrass density was only about 20–30% of the continous wheat rotation. This was due to the higher rates of trifluralin and an alternate grass herbicide were used in the peas.

These results show the value of IWM and crop rotation in managing weeds in a continous cropping rotation.

***Source: Fettell, 2000.***

Photo: A. Johnson

*Wheat plants.*

*Table 1.4 Ryegrass density in continuous wheat from long term trials conducted at Condobolin Agricultural Research Centre.*

| Tillage system | | Ryegrass counts taken | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | August 1993 post-herbicide | May 1995 pre-sowing | July 1995 no herbicide | August 1996 pre-herbicide | July 1997 pre-herbicide | August 1998 pre-herbicide | October 1998 post-herbicide | July 1999 pre-herbicide |
| | | ryegrass density /m² | | | | | | | |
| Traditional | Stubble burnt, cultivated (scarifier) | 1 | 4 | 1 | 1 | 1 | 0 | 0 | 8 |
| No till | Stubble burnt, direct drilled | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 2 |
| Stubble incorporated | Incorporated (offsets & scarifier) | 6 | 104 | 36 | 189 | 141 | 213 | 41 | 293 |
| Stubble mulched | Stubble retained, cultivated (chisel) | 10 | 190 | 85 | 204 | 195 | 240 | 28 | 396 |
| Stubble retention | Stubble retained, direct drilled | 2 | 33 | 5 | 13 | 34 | 60 | 15 | 241 |

### *Case Study 1.3 Using a double knock*

A double knock is where survivors of any weed control tool are killed or suppressed by an alternate tool. Any two weed control tools carried out together or close together can be described as a double knock (Table 1.5). For example, if there is regrowth following a silage cut (first knock), a herbicide (second knock) to take out the regrowth can be used.

The knocks can be simultaneous e.g. a herbicide mixture instead of a single herbicide or can range between one to 10 days apart. A short period for small actively growing weeds with a uniform emergence or longer periods for cool, slow growing conditions.

If there is a long delay between knocks it is likely that more weeds will germinate and emerge after the first knock. Since these weeds were not treated with the first knock they are not considered as having been exposed to a double knock.

For example, a cultivation followed a couple of months later by a herbicide spray is not considered a double knock. Most of the weeds would have germinated after the cultivation and would be only exposed to the herbicide.

Double knockdown is a specific double knock technique where glyphosate is followed by paraquat (Spray.Seed®, Gramoxone etc.) prior to sowing a crop or pasture. It is a herbicide only technique.

***Table 1.5 Options for killing or suppressing survivors of an initial treatment as a double knock.***

| Weed control tools | Possible double knock options |
|---|---|
| Grazing | Spray top* |
| Hay production | Pre-mowing spray top |
| Silage cut | Herbicide on regrowth |
| Winter clean | Graze |
| Winter clean | Spray fallow |
| Spray fallow | Cultivate |
| Knockdown herbicide (i.e. glyphosate) | Knockdown herbicide (i.e. Spray.Seed®) |
| Pre-sowing knockdown | Full cut cultivation at sowing |
| Pre-sowing and sowing operations | Post-sowing pre-emergent herbicide |
| Competitive variety and crop density | Selective herbicide |
| Selective herbicide | Follow up alternate selective herbicide |
| Single herbicide (e.g. glyphosate) | Herbicide mixture** (e.g. glyphosate and 2,4-D) |

* Have care with herbicide choice and timing to reduce impact on clover.
** Both herbicides must be present at lethal rates in this case.
***Source: S. Sutherland 2006 pers. comm.***

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***For further information on pulse crops see the following book available from the NSW DPI and Weeds CRC.***

**Winter Crop Variety Sowing Guide**

**Weeds in Winter Pulses; integrated solutions.**

### *Case Study 1.4 Managing weeds with rotations 2. By Kathi Hertel*

| | |
|---|---|
| **Name** | Garry Evans. |
| **Property** | "Larrys Plains" Geurie (890 ha). |
| **Enterprise** | Merinos and prime lambs, steer fattening and cropping (wheat, barley, oats, albus lupins, field peas, chickpeas, linseed and canola). |
| **Landscape and soil** | Undulating landscape with heavy grey/black clay loams to sandy clay loams to sandy loams. |
| **Rainfall** | 575 mm (non seasonal). |
| **Advantages** | Lifestyle and timeliness. The entire crop program can be fallow sprayed in 3 mornings with the GPS and tramline system (3.00 am start). |
| **Disadvantages** | Reliance on chemicals. Solution may include the introduction of cover and green / brown manure crops |
| **Future directions** | "To try and stay one step ahead of the weeds". Would like to try to extend the crop phase and therefore the chemical rotation. Roundup Ready® canola would fit with this well, allowing a double knock the following year to control any resistant individuals.<br>Keeping abreast of the latest technology and ideas particularly concerning herbicide use and mixes. "If chemicals fall down, the whole system falls down." |

#### *Current farming system*

The no-till approach was adopted due to erosion induced by conventional cultivation and a better lifestyle with less hours spent sitting on the tractor (Figure 1.2).

The system also moves towards improved sustainability, maintaining and maximising ground cover and minimal soil disturbance to promote soil structure development, microbial activity and to minimise weed seed bank germinations.

Stock and crop enterprises are run separately. Sheep are run on the second class country, with better class cropping country utilised only in an emergency. Drought management includes using variable stocking rates, with steers being completely destocked early.

*Figure 1.2 Rotational sequence for (a) normal country and (b) less arable country.*

(a) lucerne → canola → wheat → barley → pulse → wheat → canola → wheat → pulse etc.

(b) canola → wheat → barley/oats → lucerne (6 years) → canola

#### *Herbicide application*

Timeliness of herbicide applications (weeds and crop growth stage, days after rain) is a key point.

Water quality is crucial. Bore water has sulphate of ammonia and LI 700 added. Sulphate of ammonia plays a role in improving herbicide absorption. Roundup CT® (Group M) and sulphate of ammonia are much more cost effective than other glyphosate formulations based on cost per gram of active ingredient.

Photo: K. Hertel

*Garry Evans.*

#### *Agronomy*

Competitive crops, particularly cereal crops are maximised through accurate seed placement and target crop densities. For example, Tilga is a vigorous barley variety which competes strongly with weeds.

Fertiliser placement is concentrated near the seed zone to encourage early crop vigour. Nitrogen is banded 5 cm below the seed with the remaining starter fertiliser placed with the seed.

#### *Fallow*

In summer spraying is 10 to 14 days after rain to allow low rates of herbicide to control weeds. Two timely low rate applications are sometimes more effective than a single late full rate application.

Try to incorporate double knockdown technique over 25% of the crop area each year.

*Table 1.6 Calender of operations on 'Larrys Plains'.*

| | |
|---|---|
| **January– March** | Fallow management as required. |
| **March** | Oats pasture cropping on lighter shallow soils |
| **End April** | Sow conventional canola and lupins. Let weeds germinate in other paddocks. |
| **May** | Apply a knockdown herbicide ahead of sowing wheat, linseed, field pea and barley. |
| **June** | Sow later wheats and barley |
| **July/August** | Apply early post-emergent weed control as necessary. Topdressing crops. |
| **September** | Late post-emergent weed control as necessary. |
| **October** | Monitoring (and control) of insect pests. |
| **November** | Windrow and harvest canola. |
| **December** | Harvest. Sow cover crop. Fallow weed control where necessary. |

### *Lucerne phase*

Two years prior to a crop, broadleaf weeds are spray grazed in winter and grasses are spray topped in the spring. In the final year of pasture, the pasture is destocked and allowed to recover for two to three weeks before applying Roundup CT® in September.

### *Cereal crop phase*

**Wheat**

Pre-emergent herbicides Logran B Power® (Group B) + Spray.Seed® (Group L) are used as part of a targeted resistance prevention strategy. Mataven® (Group K) is used for wild oat control. The priority for weed control is not cost, but avoiding the use of Group A herbicides in the cereal phase.

**Barley**

Barley is treated differently because of the effectiveness of the strategies in the previous canola and wheat crops. Where difficult weeds like black bindweed (also known as climbing buckwheat) is present 500 mL/ha MCPA Amine® (Group I) and 50 g/ha Affinity® (Group G) are used.

### *Broadleaf crop phase*

Group A (selective grass) herbicides are used in broadleaf crops only.

Only conventional canola varieties are grown. Weed control in canola is with pre-emergent herbicide, usually 1.2 L/ha Triflur X® (Group D). A selective grass (Group A) herbicide is also applied post-emergent as required.

When lupins are grown, 2.0 L/ha simazine (Group C) is applied pre-sowing with another 2.0 L/ha simazine post-sowing pre-emergent. The split application is to prevent the simazine from running into the furrows. Selective grass herbicides (Group A) are used when required.

Weed control in field peas is with 200 mL/ha metribuzin (Group C) pre-sowing with another 150 mL/ha metribuzin post-sowing but either pre- or post-emergent. Selective grass herbicides (Group A) are used as required.

### *Weed spectrum observations*

Weeds like black bindweed, marshmallow and horehound are increasing, especially in paddocks with a short pasture phase. There has been a decrease over time of variegated and saffron thistles, and barley grass. Wild oats and annual ryegrass are becoming less of a problem.

### *Future directions*

A disc seeder maybe ideal but in a mixed crop/pasture system, a tyned implement may be necessary at the end of extended pasture phase.

*Table 1.7 Crop and herbicide rotation for James Hassall "Kiewa" Gilgandra. → See Case Study 1.1 page 4*

| Crop | Herbicides Used (Herbicide Group) | | | | Total Groups |
|---|---|---|---|---|---|
| | Autumn | Winter | Spring | Summer | |
| Canola, Clearfield®** | glyphosate (M), Treflan® (D) ** | grass herbicide (A), On Duty® (B) (if Clearfield® canola) | | glyphosate (M), Surpass® or Dicamba®(I), Garlon® (I)* | 2M, D, A, B, 2I |
| Wheat | glyphosate (M) & Spray.Seed® (L) ** | Hoegrass® (A)* Glean® (B)** | Mataven L®(K) **, MCPA LVE (I)* or 2,4-D amine (I)* | glyphosate (M), Surpass® or Dicamba® (I), Garlon ®(I)* | K or A*, B, 2M, 2 or 3I, L |
| Pulse | glyphosate (M) & Spray.Seed® (L)**, simazine (C) | grass herbicide (A) simazine (C) | | glyphosate (M), Surpass® or Dicamba® (I), Garlon® (I)* | A, 2M, L, 2C, 2I |
| Wheat | glyphosate (M) & Spray.Seed® (L) ** | grass herbicide (A) * | Mataven L® (K) **, MCPA LVE (I)* or 2,4-D amine (I)* | glyphosate (M), Surpass® or Dicamba® (I), Garlon® (I)* | K or A*, 2M, 2 or 3I, L |

James also comments "We realise that being solely reliant on herbicides for weed control will lead to plants becoming resistant to particular herbicides if we fail to actively rotate our chemical groups. We rely heavily on our consultant agronomists, IMAG Consulting in our case, to monitor weed burdens, plan appropriate chemical rotations and most importantly, make objective chemical recommendations."

Assessment: The high risk herbicides (Group A and B) are rotated with each group only used every second year. Groups C and D are also only used once in every four years. There is a high use of Group M and I products in summer however continued strategic use of Group L products can reduce the potential for an increase in glyphosate tolerant weeds such as heliotrope and fleabane.

* As necessary.
** As dicated by herbicide mode of action rotation.

*Table 1.8 Crop and herbicide rotation for Garry Evans "Larrys Plains" Geurie. → See Case Study 1.4 page 10*

| Crop | | Herbicides Used (Herbicide mode of action group) | | | | Total Groups |
|---|---|---|---|---|---|---|
| | | Autumn | Winter | Spring | Summer | |
| Yr 1 Canola | | glyphosate (M), Trflur X® (D) | grass herbicide (A)* | | glyphosate (M), Surpass® (I), Garlon® (I) * | 2M, 2I, D, A, |
| Yr 2 Wheat | | Spray.Seed® (L), Logran B Power® (B) | | Mataven L® (K) * | glyphosate (M), Surpass® (I), Garlon® (I) * | L, M, 2I, K, B, |
| Yr 3 Barley | | glyphosate (M) | | MCPA amine (I) * Affinity® (G) * | glyphosate (M), Surpass® (I), Garlon® (I) * | 2M, 3I, G, |
| Yr 4 Pulse | Lupins | glyphosate (M) simazine (C) | simazine (C), grass herbicide (A)* | | glyphosate (M), Surpass® (I), Garlon® (I)* | 1 or 2M, 2C, A, 2I, |
| | Field peas | metribuzin (C) | metribuzin (C), grass herbicide (A)* | | | |
| Yr 5 Wheat | | Spray.Seed® (L), Logran B Power® (B) | | Mataven L® (K) | | L, B, K |
| Yr 6 Lucerne | | grazing | grazing 2,4-DB or Jaguar® (C+F) | grazing | grazing | I or C+F |
| Lucerne (3–5 years) | | grazing | grazing | grazing | grazing | |
| Lucerne (2nd last year) | | grazing | broadleaf weeds spray grazed MCPA amine | grasses spray topped glyphosate | grazing | I, M |
| Lucerne (final year) | | grazing | grazing | Sprayed out with Roundup CT® (M) | | M |

Garry's observations: Weeds like black bindweed, marshmallow and horehound are increasing, especially in paddocks with a short pasture phase. There has been a decrease over time of variegated and saffron thistles, and barley grass. Wild oats and annual ryegrass are becoming less of a problem.

Assessment: The increase in bindweed and horehound is due to the high reliance on glyphosate in summer. Herbicides are rotated; Group A and B products are each used twice every five years during the cropping phase, Group C and D are used once each every five years.

* As necessary

### *Using herbicides on your farm*

This page is for you to examine which herbicide modes of action are used in your own current rotation.

*Table 1.9 Track your own herbicide use.*

| Herbicides Used (Mode of action) | | | | | Total Groups Used |
|---|---|---|---|---|---|
| Crop | Autumn | Winter | Spring | Summer | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

➤ *See pages 76–77 to check if your are following the industry recommendations for herbicide rotation.*