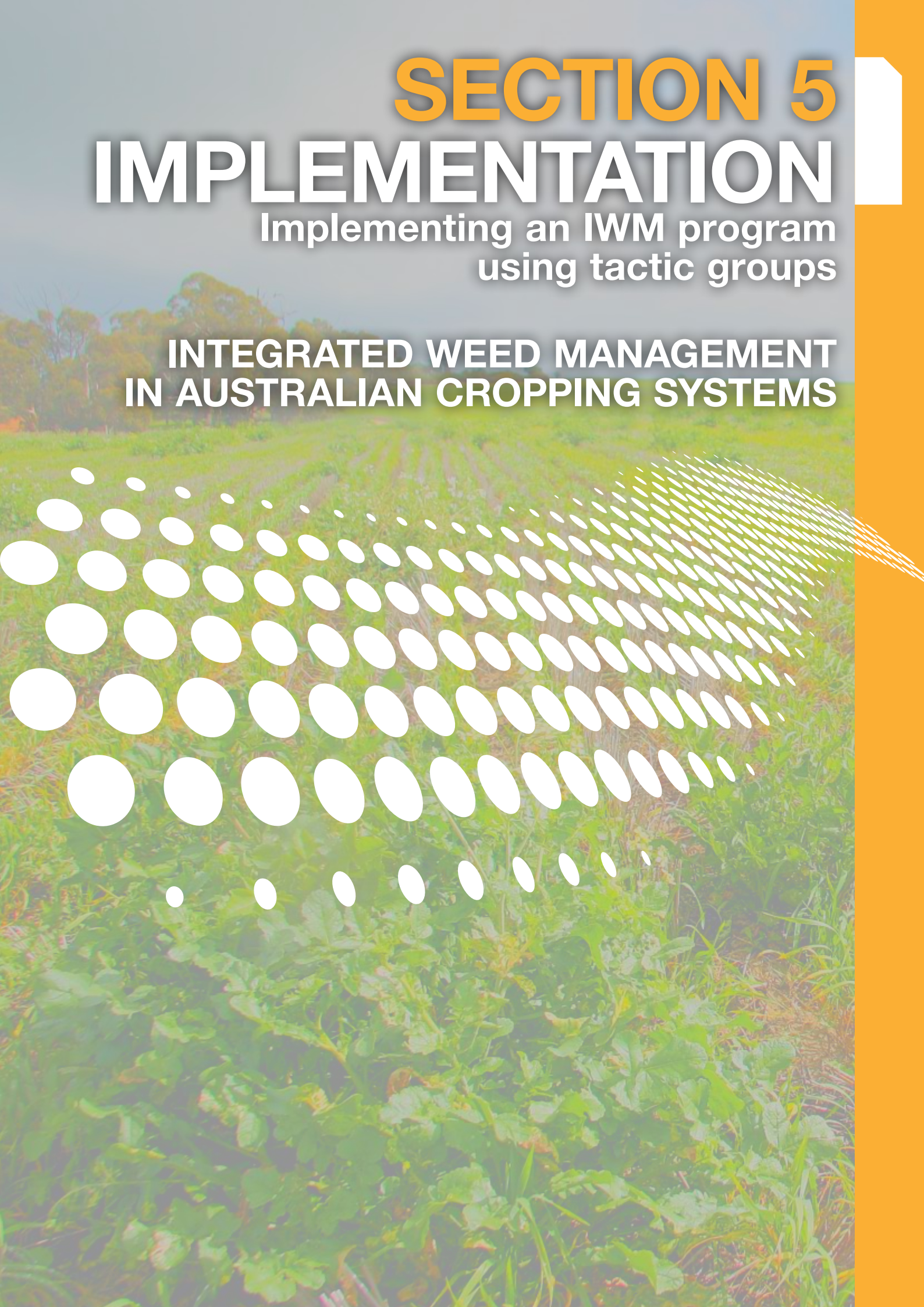
SECTION 5
IMPLEMENTATION
Implementing an IWM program using tactic groups

INTEGRATED WEED MANAGEMENT IN AUSTRALIAN CROPPING SYSTEMS



SECTION 5: IMPLEMENTING AN IWM PROGRAM USING TACTIC GROUPS

Successful integrated weed management (IWM) depends on having:
- clear weed management objectives
- a well-defined plan.

In general, the key weed management objective will be to reduce both weed numbers and the size of the weed seedbank in the soil. There may also be specific objectives for each farm business, or each paddock within a farm business. For example, managing a herbicide resistant weed population may be a specific objective within one paddock, while avoiding the introduction (or spread) of a specific weed may be an objective in another paddock.

A plan should be developed for each paddock or management zone based on the following five steps:
1. Review past actions.
2. Assess the current weed status.
3. Identify weed management opportunities within the cropping system.
4. Match opportunities and weeds with suitable and effective tactics.
5. Combine ideas using a rotational planner.

Use *Section 6 Profiles of common weeds of cropping* (page 249) (and other resources) to develop a full understanding of the target weed. Then use *Section 4 Tactics for managing weed populations* (page 91) (and other resources) to research the weed management tactics available and the likely benefits, impacts and limitations of each tactic, including those not directly related to weed management. Match the tactics to the weed and the farm business. Consider fine-tuning agronomic practices (see *Section 3 Agronomy to enhance the implementation and benefits of weed management tactics*, page 53) to enhance the impact of the weed management tactics being used.

Step 1: Review past actions

History of herbicide use

Managing herbicide resistance evolution in weed populations requires a good knowledge of past herbicide use. A record of all herbicides previously applied will flag any herbicide groups and weeds that may be at a more immediate risk of developing resistance.

Collate herbicide use information on a paddock-by-paddock basis for as many years as records are available.

The IWM plan should be:
- flexible (i.e. able to respond to seasonal conditions)
- based on a good understanding of the life cycle and characteristics of the target weed or weeds
- based on thorough knowledge of the farm (i.e. climate, soil and history)
- linked to long-term goals of the farm business
- cost-effective in the medium to long term.

When there are greater than acceptable numbers of survivors from an application of herbicide (taking into consideration the meteorological conditions when it was applied), good records can help identify whether resistance is a likely cause.

The history of herbicide use information can then be used to:
- prioritise weed management tactics so as to avoid the use of high-risk herbicide mode-of-action (MOA) groups in paddocks with numerous applications or use of high rates in the past

- identify those paddocks at risk, where weed populations can be prioritised for resistance testing and for more detailed monitoring of weed numbers and distribution.

Information on the effectiveness of herbicides applied can be used to save time and money by highlighting potential herbicide resistant populations. Where control has been unsatisfactory, make a record of the target weed and the situation in which it is growing, the growth stage and health of the weed and any possible explanation as to why the tactic failed (e.g. incorrect use of the tactic, poor application technique or timing, adverse weather conditions).

History of non-herbicide tactic use

Gather as much information as possible on any non-herbicide tactics that have been used in the past, whether or not they were targeting weed management, and an indication of how effective they were at reducing weed numbers. Record, for each paddock, events such as:

- cultivation, including 'light' cultivations
- residue burning
- slashing or mowing
- silage and hay cuts
- stubble grazing
- rotational changes such as pasture production.

Step 2: Assess the current weed status

Record the key weed species (see *Section 6 Profiles of common weeds of cropping*, page 249), including in-crop and fallow weeds, and the distribution and density of each. Always note the date when making paddock assessments.

When recording the distribution of each weed across the paddock, observe if it is:

- widespread and scattered at low plant density
- widespread and at high plant density
- in a small localised area and, if so, where
- in high density patches and, if so, where.

When recording the plant density of each weed, observe the distribution of the weed across the paddock. If the weed is distributed uniformly, estimate the average density. If it occurs in patches, assess the average density within those discrete areas (see *Assessing weed population density,* page 244).

Together, distribution and density give a clear picture of the weed status at a given time. Thorough and repeated (perhaps annual) weed assessment records effectively identify changes in weed species and distribution within a paddock and across the farm. While conducting these observations any new weed introductions will also be identified.

A global positioning system (GPS) or physical markers can be used to map the location of isolated weed incursions or weed patches so they can be tracked and managed from year to year.

Current herbicide resistance status of weed populations

To ensure effective and economical management decision-making in the future, it is essential to determine why weeds survive an application of herbicide. If the reason for herbicide failure cannot be clearly and confidently determined, the weed population should be tested for herbicide resistance (see *Assessing herbicide performance*, page 245).

A positive test result confirms the need for alternative tactics or herbicides. An incorrect assumption about the herbicide resistance or cross-resistance status of a weed population can be very expensive. Further application of an inappropriate herbicide will only lead to a build-up of the herbicide resistant weed seed levels in the seedbank, increasing the magnitude of the problem (see *Herbicide resistance testing,* page 246, and *Section 2 Herbicide resistance*, page 27).

Step 3: Identify weed management opportunities within the cropping system

Weed management tactics need to complement the farming system and business goals. Ensure that proposed changes to the system are suited to the land, infrastructure and management resources, and that the inclusion of weed management tactics is practically, environmentally and economically sound. Be aware of likely constraints to implementing weed management tactics such as:

- enterprises within the business that limit the use of some tactics (e.g. canola and some soil residual herbicides)
- the farming system employed (e.g. cropping only)
- personal preferences (e.g. no-till, aversion to change, preference for livestock)
- financial situations or poor availability of contractors or markets
- soil types and/or environment.

Identification of constraints helps define opportunities for controlling weeds and the available weed control tactics. Discussing such issues with the grower will help ensure that later advice meets the needs of the farm business.

Sometimes the use of a weed management tactic may provide an opening for a new enterprise. For example, production of high-value legume silage may represent a profitable new enterprise as well as being a valuable tool to manage weed seedbanks.

Weed management plans should be flexible. Regular reviewing ensures that tactics can be added or removed as needed.

Computer simulation and decision support tools

Computer simulation tools can be useful to run a number of 'what if' scenarios to investigate potential changes in management and the likely effect of weed numbers and crop yield. Two simulation tools being used are the Weed Seed Wizard and RIM (Ryegrass Integrated Management).

Weed Seed Wizard

The Weed Seed Wizard is a computer simulation tool for use in cropping situations across Australia. It can be used to explore different weed management scenarios side by side and help users decide where a new practice (or tactic) or rotation may fit into their specific system and location.

The 'Wizard' uses farm-specific management inputs and modelled competition to predict grain yield and weed seed production. Changing management practices can alter crop or weed numbers. This will affect grain yield as well as the number of weed seeds produced and their subsequent return to the seedbank.

The input of management practices into the model is very flexible. It is based on a timeline using specific management records and can be used to look at past or future years:

- Users can input what crop they have sown in the past or what they may sow in the future, the specific sowing times and rates as well as the viability of the seed.
- Specific herbicides or mixtures can be added and their control percentages quickly adjusted to portray herbicide resistance or poor herbicide application, for example.
- Particular harvest management strategies can be inputted and subsequently changed to suit the location, for example where a wet harvest affects the amount of weed seed dropped or where rain after haymaking may allow weeds to regrow and set seed.

The 'Wizard' fine-tunes to specific locations:

- Multiple weed species can be considered simultaneously for the same paddock and users can choose their particular weed species from annual ryegrass, brome grass, barley grass, silver grass, wild oats, wild radish, fleabane, common sowthistle, feathertop Rhodes grass, liverseed grass, barnyard grass, sweet summer grass, paradoxa grass and bladder ketmia.

- Users choose their own weather file. The specific weather predicts the loss of dormancy for each weed species and matches this with the rainfall to determine the timing of their emergence from the weed seedbank.
- Users also choose their soil type. The different soil types combine with the weather file to determine how much water is in the soil profile and when germination will occur.
- Different tillage practices can be added. The 'Wizard' matches where the weed seed is within the soil profile from the chosen tillage practice with the soil moisture of the chosen soil type to further predict the germination of each weed species.

The development of the Weed Seed Wizard was funded by the Grains Research and Development Corporation, Department of Agriculture and Food Western Australia, University of Western Australia, New South Wales Department of Primary Industries, University of Adelaide and Department of Agriculture, Fisheries and Forestry, Queensland. A free download is available from: https://dafwa.agric.wa.gov.au/weed-seed-wizard-0.

RIM

Ryegrass Integrated Management,or RIM, is a decision support tool designed to provide growers and consultants with insights into the long-term management of annual ryegrass in dryland broadacre winter cereals facing development of herbicide resistance. RIM offers a convenient way to assess and compare the profitability of alternative strategic and tactical ryegrass management methods. The software's underlying model integrates biological, agronomic and economic considerations in a dynamic and user-friendly framework, at paddock scale and over the short-term and long-term.

The user first customises a paddock profile (yields, herbicides and other control methods, machinery, etc.), then builds a rotation and defines a management strategy over a 10-year timeframe. Rotation enterprises include wheat, barley, legumes and pastures, with over 40 field operations available. Ryegrass control methods include combinations of chemical, mechanical and cultural options. The tool tracks the changes through time with regard to the ryegrass seed germination, seed production and competition with the crop. Long-term effects over several seasons are accounted for through the carryover of ryegrass seeds into the next step of the rotation.

Additional features include settings for an easy customisation as well as the possibility to visually compare two different strategies or paddock profiles in terms of seedbank dynamics, ryegrass burden on yields, budget allocation for various weed control techniques, and overall profitability.

RIM is available free for download along with further information at www.ahri.uwa.edu.au/RIM

Step 4: Match opportunities and weeds with suitable and effective tactics

Tactic groups

Just as herbicides can be grouped by mode-of-action (MOA), tactics for weed control can also be assigned to one of five groups (Table I1, page 242). Each tactic group provides a key opportunity for weed control and is dependent on the management objectives and the target weed's stage of growth.

Step 5: Combine ideas using a rotational planner

A rotational planner is a useful and simple way to pull together an IWM plan. It needs to be drafted for each paddock and should include details such as:

- key weeds
- soil type(s)
- soil pH
- management issues and resistance issues (current and/or future)
- key weed management objectives that need to be addressed
- crop and pasture rotations
- selected weed management tactics from the different tactic groups
- plans for herbicide use (in-crop and fallow).

The preliminary rotational planner can be reviewed and improved from both weed management and economic perspectives by asking questions such as:

- Will this plan be effective in reducing the weed seedbank of key target weeds?
- Is the plan likely to lead to economical and sustainable crop production?
- Are there significant areas of risk if aberrant seasonal conditions or other unexpected events occur?
- Is there flexibility within the plan?

TABLE I1 Tactic groups used to aid weed management planning.

Tactic group (TG)	Opportunity/timing	Weed impact	Tactic
TG1 Deplete weed seed in the target area soil seedbank (page 92)	Fallow Stubble Pre-sowing Pasture phase	Encourage germination of weeds – and subsequently kill them	*Tactic 1.4 Autumn tickle*, page 105 *Tactic 1.5 Delayed sowing*, page 109
		Reduce viability of weed seed in the seedbank	*Tactic 1.1 Burning residues*, page 92 *Tactic 1.3 Inversion ploughing*, page 101 *Tactic 4.2* Grazing crop residues*, page 222
		Removal of weed seeds from the seedbank	*Tactic 1.2 Encouraging insect predation of seed*, page 98 *Tactic 3.5* Grazing – actively managing weeds in pastures*, page 202 *Tactic 4.2* Grazing crop residues*, page 222
TG2 Kill weeds (seedlings) in the target area (page 113)	Fallow Pre-sowing Early post-emergent herbicides Pasture phase	Kill weeds, particularly seedlings	*Tactic 1.1* Burning residues*, page 92 *Tactic 2.1 Fallow and pre-sowing cultivation*, page 113 *Tactic 2.2a Knockdown (non-selective) herbicides for fallow and pre-sowing control*, page 124 *Tactic 2.2b Double knockdown or 'double knock'*, page 128 *Tactic 2.2c Pre-emergent herbicides*, page 133 *Tactic 2.2d Selective post-emergent herbicides*, page 139 *Tactic 2.3a Inter-row shielded spraying and crop row band spraying*, page 150 *Tactic 2.3b Inter-row cultivation*, page 153 *Tactic 2.4 Spot spraying, chipping, hand roguing and wiper technologies*, page 156 *Tactic 2.6 Biological control*, page 160
TG3 Stop weed seedset (page 170)	Pasture phase Late fallow Late stubble In-crop	Controlling weed seedset while maintaining yield	*Tactic 2.4* Spot spraying, chipping, hand roguing and wiper technologies*, page 156 *Tactic 3.1a Spray-topping with selective herbicides*, page 172 *Tactic 3.1b Crop-topping with non-selective herbicides*, page 174 *Tactic 3.1c Wiper technology*, page 178 *Tactic 3.1d Crop desiccation and windrowing*, page 181 *Tactic 3.2 Pasture spray-topping*, page 184 *Tactic 3.3 Silage and hay – crops and pastures*, page 190 *Tactic 3.5 Grazing - actively managing weeds in pastures*, page 202
		Controlling weed seedset while sacrificing yield	*Tactic 3.4 Manuring, mulching and hay freezing*, page 195
TG4 Prevent viable weed seeds within the target area being added to the soil seedbank (page 212)	Pasture phase Late crop salvage Harvest	Physical removal of viable seed from paddock	*Tactic 1.1* Burning residues*, page 92 *Tactic 3.1d* Crop desiccation and windrowing*, page 181 *Tactic 3.3* Silage and hay – crops and pastures*, page 190 *Tactic 4.1 Weed seed control at harvest*, page 212 *Tactic 4.2 Grazing crop residues*, page 222
TG5 On-farm hygiene (page 228)	Sowing Fallow Stubble In-crop Pasture phase Farm operations Livestock feeding Floods	Whole farm hygiene	*Tactic 5.1a Sow weed-free seed*, page 229 *Tactic 5.1b Manage weeds in non-crop areas*, page 231 *Tactic 5.1c Clean farm machinery and vehicles*, page 232 *Tactic 5.1d Manage livestock feeding and movement*, page 233 *Tactic 5.1e Monitor paddocks following flood for new weed incursions*, page 234

*Tactic used outside its main tactic group, supporting the primary ones within that group.

Review the results

The plan should be reviewed to assess its impact on the target weed(s). Monitor outcomes to determine the effectiveness of each tactic and the combination of tactics for each paddock. Decide which tactics had the biggest impact on weed numbers (and why) and which tactics were disappointing (and why).

Adapt the rotational plan as needed depending on seasonal conditions and results achieved. Always be open to new ideas and practices.

WeedSmart®

WeedSmart® is an initiative that promotes the long-term sustainability of herbicide use in Australian agriculture by being a herbicide resistance management focal point for farmers and agronomists.

WeedSmart® closely follows the principles laid out in this manual. These core principles help Australian agronomists fight herbicide resistance and start winning the battle against weeds.

Must do

1. Act now to stop weed seedset.
2. Capture weed seeds at harvest.
3. Rotate crops and herbicide modes-of-action.
4. Test for resistance to establish a clear picture of paddock-by-paddock farm status.
5. Aim for 100 per cent control and monitor every spray event.

and then ...

6. Don't automatically reach for glyphosate.
7. Never cut the on-label herbicide rate and always carefully manage spray drift and residues.
8. Plant clean seed into clean paddocks with clean borders.
9. Use the double knock technique.
10. Employ crop competitiveness to combat weeds.

For more information on WeedSmart® go to www.weedsmart.org.au

Useful skills

Weed identification

Correct weed identification is critical to the selection of appropriate control tactics. Resources to assist with weed identification include: the *Ute Guides*, websites, reference books, agronomists, local council weeds officers and herbaria located within each state. A weed identification course will help identify the key features of plants used to distinguish one from another.

PHOTO: ANDREW STORRIE

An example of a good weed photograph, showing the whole plant, with good detail of leaves and stems to aid identification.

Collecting and submitting plant samples for identification

If taking weed samples to assist with identification, a few basic collection principles need to be observed. These are:

- Submit fresh samples. Collect as close to the time of identification as possible and store in a plastic bag in the refrigerator. If practical, an alternative is to plant the weed in a pot. When collecting and transporting weeds, ensure that the plant and accompanying soil are contained so there is no risk of spread.
- Submit as much of the plant as possible including the underground parts. Dig up the plant and shake off the loose soil surrounding the root system. Gently washing the roots is also helpful but take

care, as the original seed (point of germination) may still be attached and could assist with identification.

- Where possible provide flowers, seeds or fruit, as these are the most distinctive features for identification. Failure to provide these parts may prevent successful identification.
- If a range of growth stages or plant health states are present, it is essential to provide representative plants from each.
- Provide the following information: name (with address and contact details), the situation in which the plant is growing (location, soil type) and distribution (e.g. scattered, clumps, single specimens) and any information that may assist with identification. Such additional information could include:
  - Is the weed growing where imported fodder has been fed out?
  - Have particular weed management tactics been used in the current season?
  - When did you first notice the weed?

Digital photos can sometimes be useful for weed identification. Useful features to include are:

- the whole plant, showing architecture: is it prostrate, erect, a bush, a vine, etc? Include an object such as a coin or ruler to indicate size.
- the key parts of the plant including leaf shape and colour, flowers, fruit, seeds and underground parts such as bulbs.

When taking digital photos be sure that the weed can be distinguished from the background (e.g. other plants, soil) and ensure that shadows do not obliterate the weed, especially its key features. Fill-in flash can be useful, but do not submit over-exposed images. Check that the photos taken are in focus and not blurry.

Assessing weed population density

The most accurate way to estimate the population of a weed in a paddock is to count the number of plants in an area of known size at a number of locations. Weed plant counts should be done using a quadrat, which may be square or circular. The number and location of counts needed to estimate the population will vary depending on the distribution pattern.

How big should the quadrat be?

The size of the quadrat will depend on the density of the weeds. Small quadrats (0.1m^2) are adequate for weed populations greater than 200 plants per m^2. This would equate to counts above 20 plants per quadrat. For lower weed densities increase the quadrat size (up to 1m^2) so that you are counting between five and 50 plants per count.

PHOTO: JOHN HOSKING

Plants ready for pressing between sheets of dry newspaper before sending for identification.

1. If the weed is in distinct patches across the paddock:
   - Conduct plant counts within the patches only.
   - Do at least five counts within each of at least four patches, giving 20 counts for the paddock. The more counts carried out, the more accurate the assessment.

2. If weeds are relatively uniformly distributed across the paddock:
   - Conduct a transect. Walk in a line across the paddock taking a set number of steps, then do a plant count (e.g. walk in a 'W' path as in the diagram and do a count at each 'x'). The most important thing is to do at least 20 counts ensuring you have covered the majority of the paddock. Do not simply concentrate your counts in one corner of the paddock.

Record the plant count for each weed species being monitored. Plant counting is an opportune time to make notes on different aspects of the weeds and the crop. Consider whether plants appear small and stunted, or affected by insects or disease. Make observations on their distribution, such as whether they are all growing in the crop row with no weeds in the inter-row, or if the density is higher in the header trails.

Also take note of other weeds present. Records should be able to be interrogated to show changes in weed density and spectrum over time. These records can be an early warning of an emerging problem.

Estimating potential weed population density

Potential weed population density can be estimated in a number of ways, such as:

- When weeds are setting seed, count the number of seed-heads or pods, and the number of seeds per pod or seed-head, from a given sample area. This will give an estimate of the total number of seeds produced.
- A more complex but accurate method is to take soil cores, sieve and wash them, and count the seeds in those samples. This technique is often limited to use as a research tool as it is time consuming and dependent on seed identification skills.
- Water small areas in the paddock and identify and count the germinating weeds. This can be done in the autumn but does not always provide a realistic guide to the potential weediness due to the complex nature of seed dormancy.
- Use paddock records from past monitoring to give an estimate of aspects such as weed species, density, seedset and location. This allows you to monitor changes through time.

Assessing herbicide performance

Understanding how different herbicides work helps when assessing herbicide performance. It is important to remember that the rate at which plants die after the application of herbicide depends on the product and rate applied as well as the weather conditions following application. For example, the effect of paraquat/diquat on weeds can be observed shortly after spraying, with initial effects being observed within hours in bright sunlight and significant effects evident in a few days. Herbicides such as the sulfonylureas, however, are slower acting and it may be up to six weeks after application before final assessments of their effectiveness can be made.

In addition, it is important to understand the claims made by the herbicide manufacturer. Some products registered for the control of weeds do not claim to kill the weed but, rather, 'suppress' growth, reducing seedset and competition against the crop.

Herbicide failures occur for numerous reasons, including application error, adverse environmental conditions, plant stress and herbicide resistance. Spray and paddock records play an integral role in the effective assessment of herbicide performance.

Evaluate the likelihood of application error by asking:

- Has the target weed been accurately identified?
- What product was used, and was it a correct choice for the target weed?
- Was the correct product rate used for the weed growth stages present?

- Were appropriate adjuvants used at the correct rates?
- Did the product reach the target? Certain herbicides may be intercepted and bound to other plant material (e.g. stubble) or soil and thus not reach the target weed.
- Was the product measured accurately when making up the spray tank mix?
- Was the water quality satisfactory? Herbicide performance may be affected by water quality characteristics such as hardness, pH, salinity and clay content.
- Was the water volume per hectare appropriate?
- Was the boomspray accurately calibrated?
- Were there equipment problems (e.g. blocked nozzles, erratic pump performance)?
- Were the correct nozzles, pressure settings, boom height and boom speed used to achieve uniform coverage?
- Were label directions regarding environmental spray conditions observed?
- What else was added to the tank mix? Some pesticide mixtures, while being physically compatible (i.e. they can be mixed together) may be biologically incompatible. Biological incompatibility can result in reduced weed control and/or increased crop damage. For example, the tank-mixing of glyphosate and 2,4-D are biologically incompatible with some plants of the family Asteraceae, such as sowthistle (*Sonchus* spp.). These herbicides should be applied sequentially for these weeds. Performance may also be reduced if insufficient time has been left between separate applications of antagonistic products.
- Was the tank solution mixed properly and was agitation adequate to keep it mixed? This is particularly important for 'dry' formulations.

Environmental factors or conditions at the time of spraying can influence the performance of herbicides. When assessing performance problems, good records of the conditions at the time of spraying are critical.

Herbicide labels provide guidance as to desired conditions or, alternatively, conditions to avoid when spraying weeds. Unfortunately, due to the nature of weather, the number of ideal spray opportunities in a season is limited. Critical environmental factors to consider include:

- the time of day applied
- the presence of heavy dew
- the temperature at time of application (high and low) and up to 10 days before or after application
- clear skies versus heavy clouds or overcast conditions
- rainfall (e.g. whether rainfall has occurred after application and before the rain-fast period of the post-emergent herbicide has elapsed). Heavy rain shortly after use of soil-applied herbicides can move them into the crop root zone, increasing crop damage but also possibly placing the herbicide within the weed seed zone in heavy soil types.
- stressed weeds due to many factors including too dry or wet, frosts before or after application, poor nutrition, disease or insect attack, and competition from other weeds or the crop
- soil pH, organic matter and clay contents affecting herbicide availability to weeds or the crop
- whether the product leached or was otherwise destroyed so that uptake by the target weed was limited.

Once again, good records help determine the reason for herbicide failures. Their importance cannot be over emphasised. If no reason can be found for a spray failure, herbicide application history may indicate that resistance is likely.

Herbicide resistance testing

The main reason we test for herbicide resistance is to determine which herbicides are still effective at controlling the weeds in a particular paddock. The agronomist's or farmer's gut instinct might tell them it is resistance to a particular herbicide MOA; however, experience shows this instinct can be wrong. Also this instinct does not tell the farmer which herbicides still work in certain paddocks.

Remember herbicide resistance can be different from paddock to paddock and farm to farm. When testing for resistance it is useful to understand the resistance profile of the weed population: ask which herbicides from which groups still work? When conducting resistance tests use a range

of products from different MOA groups and subgroups. This is of particular value when dealing with weed species known to develop cross-resistance (see *Section 2 Herbicide resistance*, page 27).

There are a number of different methods of testing for herbicide resistance. Resistance testing can be conducted on-farm or by a commercial resistance testing service. Tests can be performed in situ (in the paddock during the growing season), on seed collected from the suspect areas, or by sending live plant samples to a testing service.

In situ testing

An in situ test can be performed following herbicide failure in a paddock. The test should be done at the earliest opportunity, remembering that the weeds will be larger than when the initial herbicide was applied. Test strips should be applied using herbicide rates appropriate to the current crop growth stage and weed size, plus a double rate. The test strips should only be applied if the weeds are stress-free and actively growing. To more accurately assess the level of control, conduct weed plant counts before and after application. Green or dry plant weights can be measured before and after spraying for more accurate results.

In order to test a number of herbicides in situ, a small motorbike boom or firebreak boom is more suitable to conduct field trials than full sized spray equipment, as long as it can be accurately calibrated.

Due to the often late timing of in situ testing, results must be carefully interpreted, preferably with the help of an experienced agronomist.

Herbicide resistance seed tests

Seed tests require collection of suspect weed seed from the paddock at the end of the season. This seed is generally submitted to a commercial testing service. It is possible to conduct your own pot tests at home, but this can be a difficult task due to the complex seed dormancy mechanisms of some weed species, the challenge of applying product at accurate rates and the difficulty of maintaining reasonable growing conditions for the weeds in pots.

The turn-around time for seed tests is generally several months due to the need to break dormancy. This can mean that results are received very close to the start of the following growing season, usually March to April.

Approximately 3000 seeds of each weed (an A4-sized envelope full of good seed-heads) are required to test multiple herbicide MOAs. This equates to about one cup of annual ryegrass seed or six cups of wild radish pods.

Consult the testing service for more details on seed collection for herbicide resistance testing.

Syngenta herbicide resistance Quick-Test™

The Syngenta herbicide resistance Quick-Test uses whole plants collected from a paddock rather than seeds, eliminating the problem of seed dormancy and enabling a far more rapid turn-around time. In addition, the tests are conducted during the growing season rather than out of season over the summer. A resistance status result for a weed sample is possible within four to six weeks.

For each herbicide to be tested, 50 plants are required. To reduce postage costs, plants can be trimmed to remove excess roots and shoots.

The Quick-Test is a whole-plant test. Weeds (ranging in size from two-leaf stage to late-tillering or decimal wcodes 12 to 16 on the Zadoks scale for grasses and up to six leaves for broadleaf weeds) are collected and sent to the testing service by mail. In some cases plants at the early flowering stage can be tested using the Quick-Test methodology.

Upon arrival at the testing service, plants are carefully trimmed and transplanted into pots. After appearance of new leaves (normally five to seven days), plants are treated with herbicide in a spray cabinet. The entire procedure, from paddock sampling to reporting results, takes between four and six weeks, depending on postage time and the herbicides to be tested.

Unlike paddock tests, the Quick-Test is performed under controlled conditions so it is not affected by adverse weather. The age of the plants is also less critical to the testing procedure. Trimming of the plants prior to herbicide application means that herbicides are applied to actively growing leaves, thus mimicking chemical application to young seedlings. The Quick-Test has been used to test resistance in both grass and broadleaf weed species. During testing, both known sensitive and resistant biotypes are included for comparison.

Collecting seed and plant samples for resistance testing

The area to be tested may be as large as a paddock or only a small problem spot. In large paddocks you may want to consider submitting a few samples (e.g. from different management zones or soil types within the one paddock).

Before sampling, contact the particular testing service you wish to use, or an agronomist experienced in herbicide resistance management, to determine how many herbicides you will need to test. This will then determine the size of the sample required.

When sampling patches of weeds after a herbicide application failure, only collect seed or plants from these patches because you will want to know whether the cause of these patches is herbicide resistance and how strong the resistance is. Collecting seed or plants from across the paddock in a bulk sample will give an underestimate of the level of herbicide resistance. A farmer should manage the whole paddock based on the resistant patches within the paddock.

Draw a 'mud map' of the collection points or area, or use a GPS to record locations.

It is often best to avoid headlands or areas where there may have been spray misses and/or overlaps or where the application rate is questionable.

Avoid producing a sample dominated by seed from only a few plants. It is best to collect one seed-head from many individual plants within the patch. The aim is to provide the most representative sample possible. Collect enough seed or sufficient plants to cover the range of herbicides to be tested.

Contributors

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Further reading

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