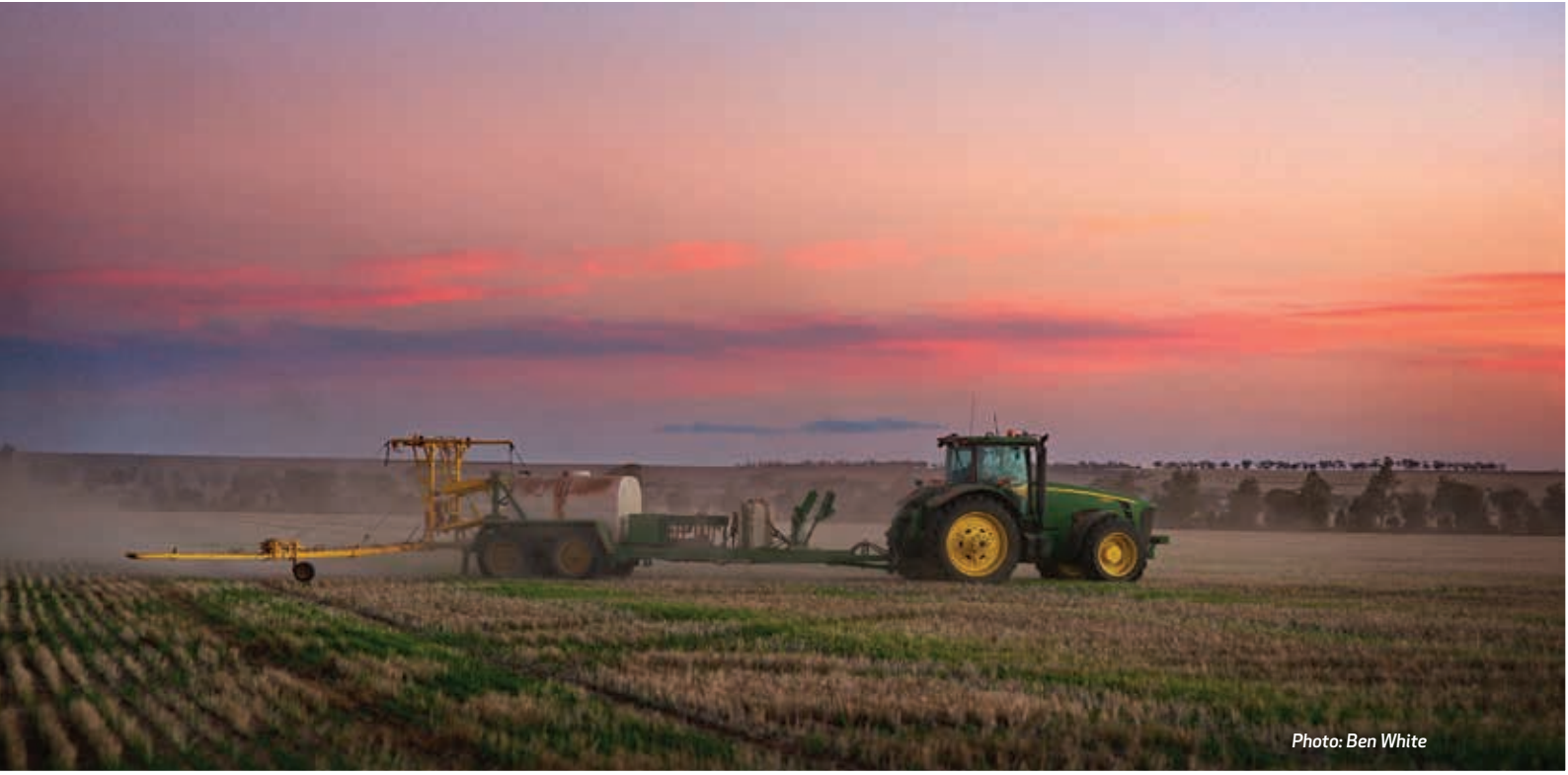


Photo: Ben White

Getting the best out of pre-emergent and post-emergent herbicides

Key facts

- Know the herbicide resistance profile of target weeds by testing paddocks regularly to develop an effective chemical control program.
- Understand the properties of different pre-emergent herbicides and how this may affect their performance.
- Consider how stubble load and cover impact on herbicide efficacy and manage appropriately.
- Use a S.T.A.R. approach when carrying out herbicide applications to maximise efficacy and manage resistance.

During the past 20 years herbicide resistance has emerged as the single most significant weed-control challenge for growers across Australia in no-till stubble retention (NTSR) cropping systems, who rely heavily on chemical weed control strategies.

Herbicide resistance was first reported in annual ryegrass on farm during 1982 near Bordertown, South Australia. Since then the problem of herbicide-resistant weeds in annual cropping systems has increased dramatically. Currently, there are 39 different weed species with confirmed herbicide resistance in Australia.

As outlined in this publication employing a strategic integrated weed management (IWM) program will prolong the life and efficacy of existing herbicides, slow down the rate of herbicide resistance in important weed species and play a role in protecting the natural resources we rely on for profitable and productive crops.

Understanding how herbicide resistance develops and following some key herbicide management strategies will help you get the most out of this important control option well into the future.

Herbicide resistance — the basics

Initially, the number of plants in any given weed species population with a natural resistance to the herbicides designed to control them exist at low levels. When a herbicide is applied to a population of weeds it will control most of the susceptible population. The naturally-resistant plants survive and set seed, increasing the proportion of resistant weeds in any given paddock over time if a herbicide with the same mode of action (MoA) is used repeatedly or survivors are not controlled using another method.

The sole reliance on the same MoA herbicides to control weeds season after season increases the speed at which resistance occurs (the actual rate of resistance also depends on the risk level of the herbicide and the genetic make-up of the weed species) — it's only a matter of time. Hence it is important to rotate the MoA groups of herbicides used to control specific weeds to delay the onset of herbicide resistance. Combining a strategic chemical control program with non-chemical methods also will help to remove resistant weeds from the system.

Not all herbicides are high risk

Herbicides are grouped based on their MoA and not all groups carry the same risk of developing resistance in weed populations (Table 2). Group A and B herbicides are the highest-risk herbicides as weed populations develop resistance rapidly

under continued use of these herbicides — as is the case with annual ryegrass. Understanding the risk profile of different herbicide options allows growers to develop a more strategic application program to slow the development of resistance and increase the overall efficacy of your weed-control program.

Testing for herbicide resistance

Many growers wait until a herbicide completely fails before they recognise they have a serious resistance problem. Regular herbicide-resistance testing of weed seedlings or weed seeds in individual paddocks is critical to prolonging the life of existing herbicide options and to delay and manage the financial impacts of herbicide resistance.

Understanding the herbicide resistance profile of your paddocks also is important when planning an effective IWM program, which involves rotating herbicide MoA groups in combination with some form of non-chemical weed control.

Pre-emergent herbicides and no-till cropping systems

No-till cropping and stubble retention (NTSR) systems have resulted in substantial benefits to Australian agriculture spanning the past 40 years. However NTSR systems rely heavily on pre-emergent herbicides to control weeds — primarily grass weeds.

Understanding the basic properties of these herbicides and paying careful attention to application practices will ensure these products have the best chance of success.

The key properties of pre-emergent herbicides to consider include the solubility (how easily they dissolve in a soil solution) and how tightly they bind to soil organic matter (SOM) and stubble (Table 3).

Highly-soluble herbicides, such as triasulfuron (e.g. Logran®) tend to require less soil moisture to be activated and absorbed by a germinating weed seedling, but can move rapidly away from the top soil and germinating seedlings after a significant rainfall event (>10mm). In contrast, herbicides with lower solubility, such as trifluralin (e.g. Treflan®) bind more tightly to SOM and stubble and therefore do not move into the soil solution or 'wash off' stubble as easily as more soluble products.

It is worth noting that insoluble or low-solubility herbicides, which bind tightly to SOM and stubble, are less effective if more than 50 per cent of the soil surface is covered with stubble.

Tips for improving the efficacy of pre-emergent herbicides in the presence of stubble:

- Increase water rates (80L/ha as a minimum) to improve overall coverage.
- Keep as much stubble standing as practical to maximise the amount of herbicide reaching the soil surface and emerging weed seedlings.
- Slow the spraying speed (16km/hr or less) to minimise 'sheeting' of herbicide on stubble.
- Spray in the same direction as the stubble rows to increase the chance of herbicide hitting the soil surface and emerging weed seedlings.
- Consider combining herbicides with different properties into the same application (always check compatibility first).
- Always use recommended herbicide rates — off-label rates will not save money and may reduce efficacy.

Basic principles of the S.T.A.R. program

Basic principles

- **Stress** — can reduce herbicide efficacy and increase crop effect. Before spraying ask:
  - Is the soil waterlogged?
  - When did it last rain?
  - Are there insect pests or disease present?
  - Have there been frosts?
  - Is crop nutrition sufficient?
- **Timing** — early spraying, when weeds are small, is usually the most effective option, returning the highest crop yields. Spraying at the optimal time:
  - ensures adequate penetration and coverage
  - minimises weed competition
  - maximises yield
  - optimises herbicide efficacy.

  Be prepared to spray twice to control later-germinating weeds.
- **Application** — correct application optimises results.
  - Check equipment, keep it clean and change nozzles regularly.
  - Follow directions on water volume, droplet size and spraying speed.
  - Only mix products that are compatible as indicated on the product label.
- **Rate** — cutting application rates does not save money and may reduce efficacy.
  - Always use recommended rates.

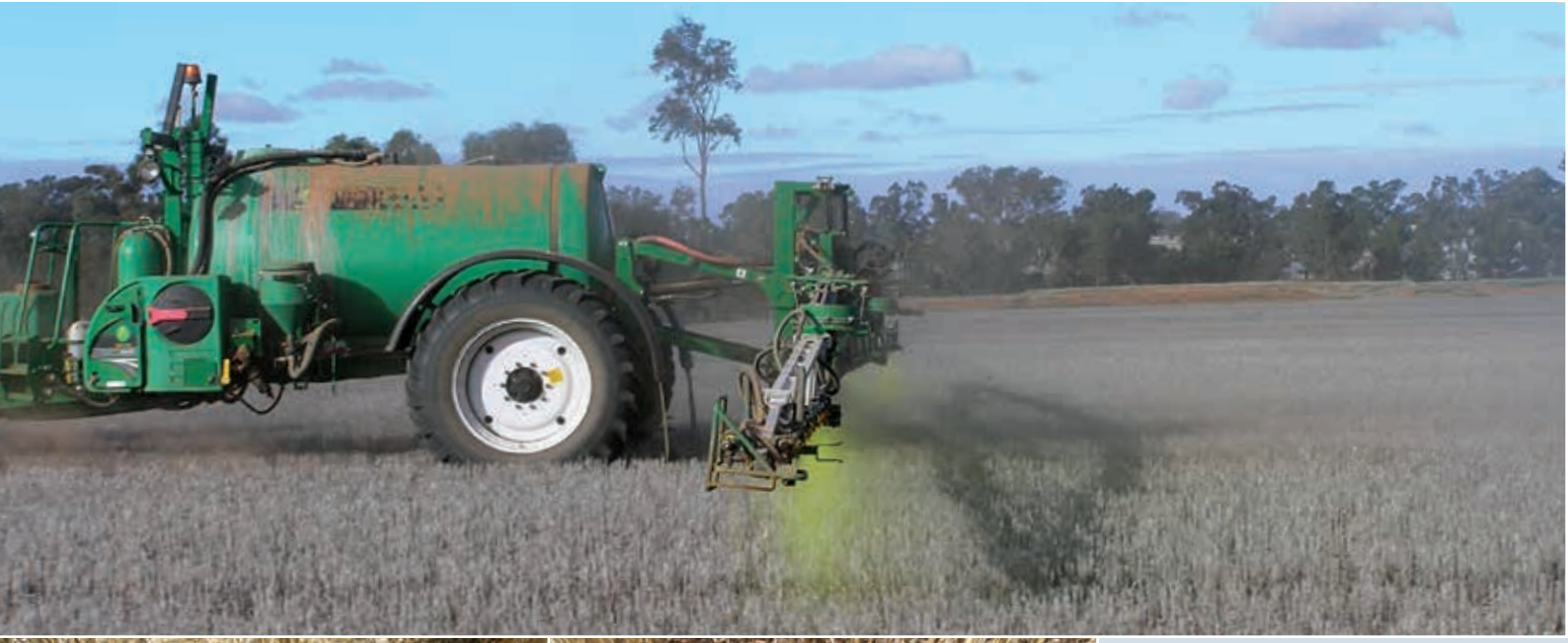
Adapted from Bayer Crop Science **http://www.bayercentral.com.au/resources/uploads/brochure/file7733.pdf**

Post-emergent herbicide success

Poor weed control results are not always due to the presence of herbicide-resistant weeds. Timing, coverage, weed size and environmental factors all influence herbicide success. The S.T.A.R. (stress / timing / application / rate) program provides a simple set of guidelines to help growers optimise herbicide efficacy and minimise the risk of failure.

Crop topping

Crop topping is an effective pre-harvest management strategy to stop seed set of weeds that have escaped pre-emergent and selective herbicide applications throughout the season. Crop topping involves applying a non-selective herbicide to flowering weeds that remain after previous applications. Timing is critical to ensure weed seeds are not filling, and the crop is advanced enough so as not to impact on grain quality. It is critical to only use a product that is specifically registered for crop topping (Table 4).



ABOVE: When choosing a pre-emergent herbicide, consider the solubility of individual products, which will affect how tightly they bind to soil organic matter and stubble. Photo: David Gooden

LEFT: Low-solubility herbicides are less effective if more than 50 per cent of the soil surface is covered with stubble (far left). Keep as much stubble standing as practical to maximise the amount of herbicide reaching the soil surface and emerging weed seedlings (left). Photos: Matt McCallum

Table 2. Common herbicides used in low-rainfall cropping regions and number of years before herbicide resistance is likely to be a problem

Herbicide group	Common actives (product example) used in low-rainfall cropping regions	Years of application before resistance is likely to be a problem	Resistance risk
A 'fop'	Haloxyfop (Verdict®), clodinafop (Topik®), quizalofop (Targa®)	6	High
A 'dim'	Clethodim (Select®), butroxydim (Factor®), tralkoxydim (Achieve®)	8	High
B	Chlorsulfuron (Glean®), triasulfuron (Logran®), imazapyr + imazamox (Intervix®), metsulfuron (Ally®), flumetsulam (Broadstrike®)	4	High
C	Simazine (Simazine 900DF®), diuron (Diuron 900DF®), terbuthylazine (Terbyne®), metribuzin (Lexone®)	10–15	Moderate
D	Trifluralin (Treflan®), propyzamide (Kerb®)	10–15	Moderate
F	Diflufenican (Brodal®)	10	Moderate
G	Oxyfluorfen (Goal®), carfentrazone (Hammer®, Affinity®)	>15	Moderate
I	2,4-D (2,4-D Amine 625®), MCPA (Agritone 750®), LVE MCPA (LVE Agritone®), clopyralid (Lontrel®), dicamba (Banvel®)	>20	Moderate
J	Triallate (Avadex®), prosulfocarb (BoxerGold®*)		Moderate
K	Metolachlor (DualGold®, BoxerGold®*), pyroxasulfone (Sakura®)	>15	Moderate
L	Diquat (Reglone®, SpraySeed®*), paraquat (Grammoxone®, SpraySeed®)	>15	Moderate
M	Glyphosate (Roundup®)	>12	Moderate
Z	Flamprop (Mataven®)		Moderate

Adapted from CropLife Australia — **http://www.croplife.org.au/** and GRDC Intergrated Weed Management Hub — **https://grdc.com.au/Resources/IWMhub/Section-1-Herbicide-resistanceresistance-strategy/2015-herbicide-resistance-management-strategies/#Mode of action**

* This product contains more than one active

Table 3. Water solubility and binding characteristics of some common pre-emergent herbicides

Herbicide	Solubility	Ability to bind to soil organic matter (SOM) and stubble	Comments	Suitability to be used in high stubble loads (>50% cover)
Trifluralin (e.g. Treflan®)	Very low	High	Ties up on SOM and stubble. Does not move far in soil. Placement relative to weed seed is very important.	Maybe
Triallate (e.g. Avadex®)	Low	High	Ties up on SOM and stubble. Does not move far in soil. Placement relative to weed seed is very important.	Maybe
Triasulfuron (e.g. Logran®)	High	Low	Very mobile in soil solution. Application relative to weed seed position not critical. Little moisture required to 'activate' herbicide.	Yes
Prosulfocarb (BoxerGold®*)	Low	High	Slight mobility. Rainfall required after application to 'activate' . Poor weed control possible if high level of stubble.	Yes
Metolachlor (BoxerGold®*)	High	Medium	Little rainfall required to 'activate' and quite mobile in soil solution.	Yes
Pyroxasulfone (Sakura®)	Low	Medium	Low water solubility so apply close to weed seeds. Can move a bit in soil solution in soils with low SOM.	Yes
Diuron (e.g. Diuron 900DF®)	Medium	High	Requires little water to 'activate' but binds tightly to SOM and stubble. Can be quite mobile in sands where SOM levels are low.	Yes
Simazine (e.g. Simazine 900DF®)	Medium	Medium	Requires little rainfall to 'activate' . More mobile than diuron.	Yes
Metribuzin (e.g. Lexone®)	High	Low	Very mobile in soil solution. Prone to moving into crop seed row with rainfall.	Yes

Source: Adapted from tables compiled by Andy Bates, Bates Agricultural Consulting (unpublished) and Barry Haskins (2012).
Haskin, B (2012) Using pre-emergent herbicides in conservation farming systems, NSW DPI.

* This product contains more than one active

Table 4. Registration status for late-season herbicide use by crop type*

	Paraquat	Diquat	Glyphosate
Wheat	No	Yes	Yes
Barley	No	Yes	No
Canola	No	Yes	Yes
Chickpeas	Yes	Yes	Yes
Lentils	Yes	Yes	Yes
Faba beans	Yes	Yes	Yes
Field peas	Yes	Yes	Yes

Source: Adapted from GRDC Late season herbicide use fact sheet — **https://grdc.com.au/uploads/documents/GRDC_LateSeasonHerbicideUse_FS.pdf**

* Always check product labels before application

Resistance testing services

- **Peter Boutsalis**
  http://www.plantscienceconsulting.com.au/
- **Charles Sturt University**
  http://www.csu.edu.au/weedresearchgroup/herbicide-resistance

Crop topping

- **GRDC Late Season Herbicide Use fact sheet:**
  https://grdc.com.au/uploads/documents/GRDC_LateSeasonHerbicideUse_FS.pdf