herbicide application

in stubble retained systems in Central West NSW

Project code CWF00018

KEY MESSAGES

- Understand herbicide properties and environmental constraints to maximise results.
- Herbicides can perform differently in varying soil types and seasons.
- Correct set- up of boom is essential for any crop or fallow type. In stubble retained systems the stubble roof becomes the 'false ground'.
- Alternate between chemical groups, consider using pre-emergent herbicides and other forms of weed control (e.g. windrow burning) to limit resistance and prolong the life of existing chemicals.
- Set up and calibrate boom sprays correctly. Follow label instructions for chemical being used.

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Overview

Over the past three decades most grain growers in Central West NSW have adopted a minimum or no-till farming system, in many cases also removing livestock from their enterprises. This has largely removed or reduced cultivation and grazing as tools for weed control, placing a higher reliance on herbicides for weed management.

Weed species in these new farming systems have seen an evolutionary change, with shallow or surface-germinating weeds suited to no-till systems becoming dominant. Growers have in many cases relied heavily on just a few of the many mode of action groups, in particular groups A, B, I and M as they are cost-effective, reliable and easy to use. Now, with weeds adapting to the new systems (i.e. surface- germinating) and being selected for increased resistance to these groups of herbicides, growers and advisors are starting to radically rethink their weed management strategies.

One option available to increase the diversity of weed management is the use of pre-emergent herbicides. However, like past options, an overdependence on this strategy will ultimately place future pressure on resistance to these modes of action as well. Therefore, non- herbicide weed management strategies need to be considered closely and included, where possible, into the cropping system to prolong the usefulness of these herbicides into the future.

There are a range of benefits when using pre-emergent herbicides as a tool within your integrated weed management strategy.

- Pre-emergents offer an alternative mode of action to many post- emergents.
- They reduce the selection pressure on post-emergent herbicides.
- Can control the early season weed burden.
- Provides cost savings in the fallow where multiple knock downs may be needed.
- Reduces time pressure on other spraying operations.
- Provides an opportunity in certain crops with limited post emergent options.

Understanding herbicide properties & environmental impacts upon a herbicide

In 2015, the GRDC published a reference manual called Soil Behaviour of Pre-Emergent Herbicides in Australian Farming Systems by Mark Congreve and John Cameron. The following is a summary of this reference as related to retained stubble farming systems. For a more technical insight on how pre-emergent herbicides work, it is recommended that growers and advisors follow links at the end of this book and read the full publication.

When applying pre-emergents it is important to understand the properties of the chemical being used.

- Its solubility (i.e. how much herbicide can dissolve in water, which is important with regard to incorporation by rainfall and germinating weed uptake).

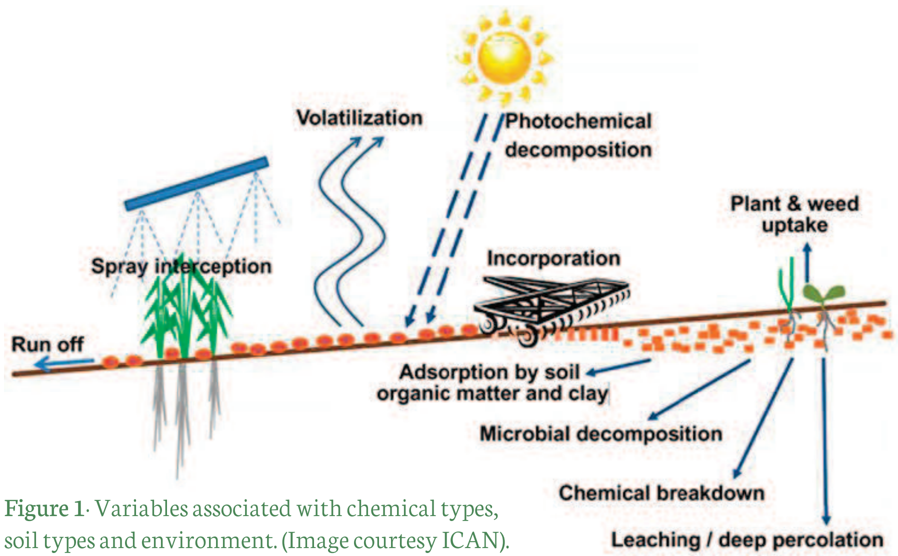

Figure 1. Variables associated with chemical types, soil types and environment. (Image courtesy ICAN).

- Its binding ability (expressed as the Soil/ Water Absorption Coefficient) which affects the mobility of a chemical within the soil and a chemical's persistence (time taken to break down in the soil).

Availability of a pre-emergent herbicide is an interaction between the solubility of the herbicide; how tightly it is bound onto soil particles and organic matter; soil factors such as structure, cation exchange capacity and pH; herbicide volatility; the environment and particularly soil water and the rate of herbicide applied. For example, some herbicides are relatively insoluble and tightly bound to soil colloids which suggest that they are unlikely to leach. Trifluralin, for example, has extremely low solubility of 0.22 milligrams per litre with a binding coefficient (Koc) of 15800, meaning it will bind very tightly to soil and stubble.

However, in a high rainfall event occurring on a dry soil, even a herbicide with these properties may move further down the soil profile before it has the opportunity to bind to the soil. This may mean the herbicide can move out of the zone where it is required for weed control, or into a zone where it can cause damage to the crop. All pre-emergents require soil moisture to activate. Weeds germinating in wet soil at depth, beneath dry topsoil with a pre-emergent chemical that is yet to be activated, are highly unlikely to be controlled.

The following image illustrates the variables associated with chemical types, soil types and environment that are then further expanded on throughout the book.

Stubble & crop interception

Stubble or existing weed cover in a zero or reduced- till fallow will intercept some of an applied pre- emergent herbicide before it reaches its target – the soil. Likewise, if the herbicide is applied as an in-crop (also known as post emergence) application, a percentage of herbicide will be intercepted by the crop. The amount of herbicide intercepted will be proportionate to the percent of ground coverage of the stubble, crop or weeds.

However, as shown in Figure 2, while this relationship is linear 50 per cent ground cover does not result in 50 per cent capture of the herbicide on the above-ground material.

Interception by standing material can have two negative effects:

1. Herbicide tied up on the stubble or in the canopy may not be available for soil incorporation and subsequent weed control. Depending on herbicide characteristics, herbicide intercepted by standing organic material will be subject to a certain level of binding.

2. Interception may lead to an uneven coverage of the soil surface, resulting in areas with insufficient herbicide coverage. Some herbicides are tightly bound to stubble and other organic material and are lost to the system in terms of weed control, despite subsequent rainfall (for example trifluralin). Others are loosely bound and relatively soluble and can be returned to the soil by rainfall that washes them off the organic material (for example chlorsulfuron).

To understand the potential level of binding of a herbicide, growers and advisers need to consider its binding coefficient (Kd or Koc) and solubility.

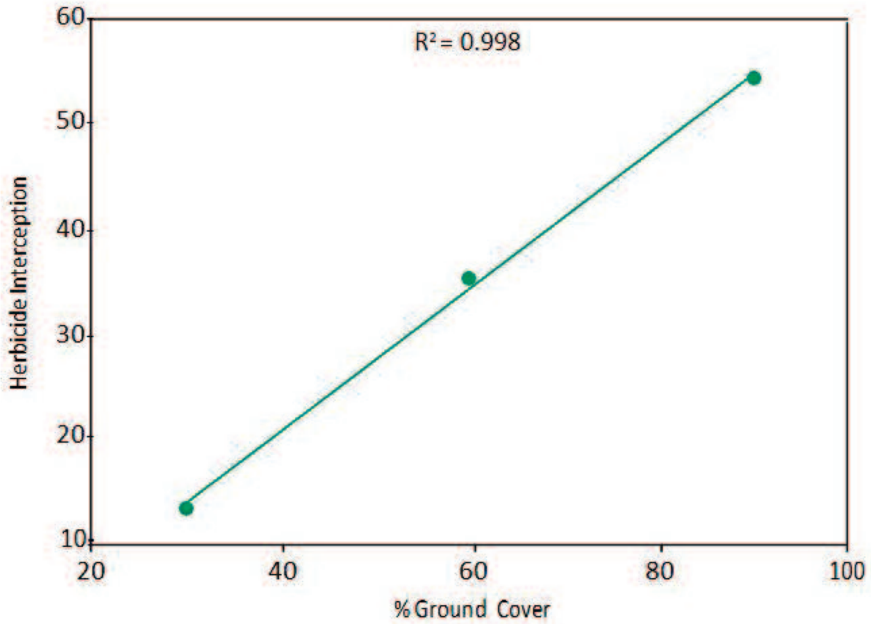

Figure 2: The percentage of herbicide captured by stubble or plant material in relation to the percentage of ground cover.

Even if a herbicide is loosely bound and available to be washed off, it still may be prone to loss due to volatility and photodegradation, before it is incorporated into the soil by rainfall.

Volatilisation & photodegradation

Volatilisation: Some pre-emergent herbicides used in the Australian grains industry are considered volatile. Volatile herbicides transition to a gaseous phase after application, if left on the soil surface without incorporation. Volatile herbicides must be incorporated soon after application to avoid significant loss to the atmosphere and therefore maintain their efficacy on weeds. If a herbicide label indicates the product should be incorporated within 24 hours, this does not mean there is no loss up until hour 23. The recommended label time for incorporation denotes the time by which the manufacturer has determined losses may start to become unacceptably high if the product has not been incorporated.

Photodegradation: Photodegradation can be significant with certain herbicides, however others are relatively unaffected by this breakdown pathway. It occurs when the herbicide undergoes a chemical reaction in the presence of sunlight and is then broken down and lost to the weed control system.

Usually standard incorporation practices such as cultivation, sowing or sufficient rainfall after application are adequate to prevent unacceptable levels of loss, however if sprayed onto a dry soil surface or dry stubble in summer with no following rainfall or mechanical incorporation, losses from this pathway may be increased.

Pre-emergents & windrow burning

If pre-emergent sprays are to be used on windrowed paddocks, the following should be considered:

- If applied over a windrow before burning, a high level of herbicide interception will occur.
- The hotter the burn the more residue is converted to ash.
- Herbicides bind more tightly to charcoal than to ash.

Incorporation

For products where incorporation is recommended or advised., the objective is to move the herbicide into the top few centimetres of soil where it will be protected from UV degradation and volatilisation, yet keep it in the zone required for weed control (which is often close to the soil surface for shallow germinating weeds, especially in zero-till systems). In retained stubble systems incorporation is usually achieved by the seeder, unlike in previous farming systems where harrows were often used. Tined seeders produce more soil throw and generally work better than disc seeders on 25 to 30cm row spacing. Careful attention should be paid to seeder set-up to ensure even inter-row coverage while preventing throw of treated soil into the next furrow. Rainfall is another method of incorporation, but if a predicted rain event doesn't occur it can lead to inconsistent results.

Herbicide behaviour in the soil

Once a pre-emergent herbicide is in the soil, a balance is established between how much is bound to clay and organic matter (and is therefore less available for plant uptake); and how much is dissolved in the soil water and available for root uptake.

Factors that affect the degree of binding are:

- The soil type (structure, pH and cation exchange capacity).
- Organic matter in the soil.
- The solubility of the compound.
- The amount of available soil moisture.
- The inherent binding strength of the molecule.

Soils with sandy topsoil have lower binding capacity than those higher in clay; more chemical becomes available to plants and may potentially damage crops. Therefore, lower rates are advisable for sandier soils.

Herbicides with low water solubility often require larger volumes of rainfall to achieve incorporation and tend to be less available in the soil moisture than more soluble products.

Typically, for optimum performance, herbicides with low solubility need good moisture conditions after application and for the period of desired weed control.

Conversely, herbicides with high solubility are relatively easy to incorporate with limited rainfall. They generally prefer to remain in the soil moisture phase and hence are more freely available to the plant or weed. However, if the herbicide is highly soluble it will have a tendency to move with the soil moisture, and be more likely to leach or cause off-target effects.

CWFS Workshops

(Nyngan 2013, Condobolin 2014)

CWFS presented workshops on herbicide efficiency and managing problem weeds in Nyngan in 2013 and Condobolin in 2014. The seminars focused on problem weeds in the CWFS area such as fleabane, sow thistle, heliotrope, windmill grass and spiny emex and their effect on stored moisture. More on the methods of control for some of these weeds are in another chapter; 'Integrated weed management'.

Heliotrope (not mentioned in the 'Integrated weed management' chapter), is difficult to control by cultivation as it will grow from pieces of broken plant as well as from seeds. In this case herbicides are the best form of control.

Water Use Efficiency (WUE):

No-till farming systems in the northern parts of the region have summer dominant rainfall areas resulting in summer weeds competing for the valuable moisture being stored in fallows for winter cropping.

CWFS spokesman John Small presented the results from five years of WUE trials in central west NSW. This research aimed to investigate WUE and how growers could produce more grain for every millimetre of rainfall received.

When it came to summer fallows the take-home message was clear: in the Nyngan district the amount of crop attributable to moisture stored in fallows in an average year is approximately 50 per cent. In the Condobolin district it is about 60 per cent, while at Tottenham it is about 70 per cent. In drier years those percentages are moderately higher. Fallow stored moisture is the biggest driver of crop yields in the Central West area.

Nutrient removal by weeds is also measurable: for every mm of fallow moisture removed by a weed, 0.7 kilograms of nitrogen is also removed. Timely application of herbicide on summer fallows and timeliness of sowing are the biggest factors influencing crop yields in Central West NSW.

[These figures are supported by research conducted in the national Water Use Efficiency Project by James Hunt, John Kirkegaard, Barry Haskins, Colin McMaster, Ian Menz, Neroli Brennan and Wes Greig].

Case Study 1:

Herbicide application on stubbles
Wes Greig, Forbes.
Agronomist with Nufarm.

Forbes agronomist Wes Greig observed many grain growers with retained stubble systems in the CWFS region were experiencing problems with their herbicide applications. In October 2015 Wes attended the CWFS spring field days and discussed correct methods of boom spray set-up, herbicide mixing techniques and other considerations for more effective herbicide results in retained stubble systems.

Correct boom spray set-up:

- To get an even deposition at the target a double overlap of spray is required. Using a boom with average 50cm spacings and a 110-degree fan angle, the double overlap will occur 50cm below the nozzles. The height of the boom should be at least 50cm above the target (i.e. weeds at ground level).
- However, when spraying into stubble the top of the stubble becomes a 'false target or ground', so the target then becomes the top of the stubble. Therefore, ideally the boom height should be set about 50-60cm above the top of the stubble. A setting that is too high can create four to eight times more drift potential.

Spraying direction:

- Spraying across stubble can cause more interception of herbicide on the stubble than spraying with the rows. This is particularly noticeable when applying pre-emergent herbicides.

Droplet size:

- A fine nozzle can result in much of the applied herbicide being captured on the standing stubble, preventing it from reaching the target (ground). If increasing to a coarser nozzle, pressure should also be increased. The coarser droplets reduce the swirling effect of the spray, resulting in a more vertical trajectory of the herbicide, particularly in windy conditions.
- Herbicides such as glyphosate that translocate readily through the plant do not require complete leaf coverage so the aim is to have sufficient droplets so that all plants get some coverage.
- Coarse and very coarse droplets will have a splash effect where the droplet explodes on impact, resulting in much better coverage of weeds within rows through thicker stubbles.
- Air induction nozzles reduce the velocity of larger droplets by incorporating an air bubble into the droplet. Using solid droplets is often better for pre- emergent herbicides trying to reach the soil.
- In higher summer temperatures, a larger droplet will evaporate slower than a finer droplet and stay wet for longer on the leaf.

Water rates:

- With coarse and extra coarse nozzles, correct water rates are important, often requiring rates above 80 l/ha where stubble is present. On bare soils a rate of 80 l/ha may be acceptable, but with standing stubble and coarser nozzles the higher water rates provide better splash and stubble penetration. (Check individual labels for details.)

Speed:

- When spraying over stubble, ground speed of the boom spray plays an important role. High boom speeds mean that droplets leave the boom with a significant component of forward momentum. This increases the percentage likely to be intercepted by standing stubble, leaving more gaps in soil coverage. Speeds below 20 kilometres an hour (and preferably less than 15km/h) are preferred in high stubble conditions.

Timing:

- In summer conditions, weeds (and especially some grass weeds) can become moisture and heat stressed quickly. As a result, weeds should be sprayed soon after emergence and from once 2 true leaves are evident. If summer rain events are relatively light and there is limited soil moisture, to protect by killing weeds, there may be a trade-off as surface moisture from a small rain event will simply evaporate and play little part in the following crop's yield unless there is follow-up rainfall.

Mixing chemicals:

- Several growers in this case study experienced what they thought were blocked nozzles or clogged filters due to either sediments in their water supply or a "bad batch" of chemical. Agronomist Wes discovered growers were mixing chemicals incorrectly (e.g. in the incorrect order), using incompatible mixes, not using enough water or not allowing sufficient time to allow product to dissolve.

View a video of Wes Greig at Northparkes Mines on boom setup or follow the link below·

https·//www.youtube.com/watch?v=rbKz-4K-ahc

View a video of Wes Greig at Northparkes Mines on mixing chemicals or follow the link below·

https·//www.youtube.com/watch?v=1XZ24aeoXnM

Case study 2:

Ryegrass resistance
Grower: Ian Luelf
Location: Weethalle, NSW.
Enterprises: Dryland wheat, barley, sheep.
Soil and pH: red sandy clay loam soils with a pH of 4.5.
Property size: 3500 ha

Overview:

Ian farms 3500ha of dryland cereals and in 2013 encountered a herbicide failure on a population of ryegrass and recognised resistance had become an issue on his property. Ian had sprayed a paddock with a high population of ryegrass with Hoegrass at the recommended label rate. Spraying conditions were ideal, but the weed response was not, so Ian sent away weed samples for resistance analysis. When resistance was confirmed, his first strategy was to move from Group A herbicides to different mode of action groups that resistant tests had shown as still working. He also began strategically cultivating to use pre-emergents such as Avadex® and Treflan™.

Ian also incorporated non-chemical weed control methods into his farming practices. He started windrowing by diverting chaff onto a tramline to introduce a harvest weed seed control tactic to help reduce the weed seedbank and delay herbicide resistance. His advice to other growers who suspect herbicide resistance after poor results from spraying is to get plant samples tested for confirmation and importantly, to see what still works. Ian said that he felt many growers were unaware of the benefits of varying herbicide groups to slow the development of resistant weeds. He advised growers to take a proactive approach to weed management, which includes mixing herbicide groups, either together or via rotation, and incorporating mechanical control strategies, such as strategic tillage.

Listen to a podcast of Ian's case study or follow the link below·

http·//cwfs.org.au/podcast/ management-rye-grass-black-oats-stubble-retained-system/

Latest research & updates

Spray drift and inversions

Spray drift:

In recent years incidents of spray drift and inversion affecting susceptible summer crops such as cotton have been widely reported. With more cotton now being grown in the CWFS region this has become a legal and management issue. Workshops have been held across the CWFS and other regions in response to this, with the topic being covered more widely in seminars updates and via media. Although the issue is not confined to spraying stubble, most summer fallows include weed control in stubbles.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has recently changed the classification of droplet sizes and this needs to be taken into account when selecting the correct nozzle size.

Apart from using coarser nozzles for larger droplet size during summer spraying in stubble (for better penetration as well as reduced risk of spray drift), other key drivers of spray drift are:

- Spray boom height.
- Speed of operation.
- Wind speed.
- Temperature and humidity.
- Spray mix formulation.

CropLife Australia has released a best practice reference guide to help boom spray operators to better manage spray drift. The guide, called MyAgCHEMuse contains the latest information on managing spray drift and can be accessed via desktop, tablet or mobile phone.

The University of Queensland has also developed the Australian Ground Spray Calculator (AGSC) based on research from their wind tunnel which is one of only two in the world of its kind. The calculator is available by emailing:

Dr Andrew Hewitt,
0427 025 354
a.hewitt@uq.edu.au or

Chris O'Donnell,
0417 413 996,
c.odonnell@uq.edu.au

Inversions:

Speaking at recent Grains Research and Development Corporation (GRDC) Updates (2017) Bill Gordon from Nufarm stated that in high risk areas and particularly during nighttime spraying that careful product and nozzle selection were imperative to reducing spray drift.

Mr Gordon stated that spraying at night has the biggest potential for risk of spray drift due to localised weather conditions and potential for inversions to form, which causes air movement at night to be totally different to the air movement that occurs during the day. There is an 80-90 per cent reduction in the risk of droplets remaining in the air when a spray operator moves from a standard coarse to an extremely coarse spray nozzle selection.

There are many papers and articles on inversions, what causes them (the earth cooling rapidly in the evening and forming a layer of warm air above it); and growers are encouraged to learn as much as possible about weather conditions where it may be unsafe to spray.

A more recent factsheet was published online by Agriculture Victoria in 2017:

http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/spraying-spray-drift-and-off-target-damage/surface-temperature-inversions

Apps and websites:

Cotton Australia has created an online mapping website for cotton farmers to map their cotton paddocks. This allows for spray operators to further assess risk to nearby cotton crops, particularly when using Group I products. An app is also now available for smartphones as a result of a joint effort between Cotton Australia, Cotton Research and Development Corporation (CRDC), Grains Research Development Corporation (GRDC) and Nufarm Search for CottonMap: http://www.cottonmap.com.au/

Apple has released an app (only available for iOS devices) called Pocket Spray Smart that delivers paddock spraying conditions, current wind speed and direction, and temperature inversion potential for your current location and each field in your Morning Farm Report® account. Available from iTunes store: https://itunes.apple.com/us/app/pocket-spray-smart/id1191688009?mt=8

Variable rate and non-chemical technologies

Selective spray units:

In recent years the development of selective spray units such as the Weedseeker and WEEDit have created a new management tool that allows operators to target specific weeds or spray individual weeds within a paddock.

The units use optical sensor technology to identify and spray individual weeds and work well in conjunction with a conventional boom spray. After a rainfall event a paddock can be blanket sprayed by a conventional boom spray. However subsequent follow up sprays throughout summer are ideal for the selective units with less chemical used and higher rates able to be applied on isolated surviving problem weeds such as fleabane and feathertop Rhodes grass.

The Swagbot at the CWFS Precision in Agriculture seminar

Drones:

Drones or unmanned aerial vehicles (UAV's) are now capable of grid mapping a paddock, identifying weeds or insects within it and if needed, spraying them. They can work autonomously and in swarms thereby covering large areas quickly. Drone technology in agriculture is advancing at a rapid rate and like the selective spray units already have a place alongside aerial spray planes and helicopters on larger properties, and are stand alone on smaller properties.

CWFS held a drone workshop in 2016 with BRALCA to expose local producers to the possibilities of drones and since then have included them in pre-season meetings in 2018 with National Drones as drone spray technology has increased.

New non-chemical technologies:

Robotic (autonomous) machinery is developing rapidly, along with new technologies that could soon be applied to broadacre farming.

The Australian Centre for Field Robotics (ACFR) at the University of Sydney has recently developed the RIPPA (Robot for Intelligent Perception and Precision Application) robot which is currently being trialed in horticultural applications.

The unit is solar powered, operates autonomously and has various tools and algorithms (programs) that can be matched to a given crop or operation. Currently, the unit can identify weeds and spray them using its Variable Injection Intelligent Precision Applicator. Trials are being conducted on identifying and vacuuming pests from horticultural crops (currently done by hand with a backpack) and developing the use of a mechanical 'finger' to remove small weeds.

ACFR has also developed the SwagBot, a more livestock based robot but with the ability to negotiate rough terrain. This unit can spot spray individual weeds and take soil samples with a mechanical arm.

SwarmFarm Robotics in Queensland is another company moving rapidly in this space with autonomous spray units designed primarily for larger cropping properties and already in use on commercial farms. Burning, laser and microwave technologies are also being explored with a company in Austria (SPL) now doing field trial work with its laser bot, 'Jati'.

In June 2017 CWFS hosted a two day Precision in Agriculture seminar, showcasing the ACFR's SwagBot and allowing them to gain insight from local farmers into creating new uses and algorithms for the unit.

View the SwagBot in action at the CWFS Precision in Agriculture seminar, or follow the link below.

www.youtube.com/watch?v=FD5kqW1Uqyo

Consumer demand & social license

There is an increasing demand worldwide for accountability and traceability in all forms of soft commodities, but particularly food. Consumers are driving the change with a higher expectation of healthy, clean and sustainable produce that is free from any pesticide. 'Health food' shops have been absorbed into mainstream commercial outlets and most packaged food now has a quality rating called 'Better For You' (BFY). As well, Australian farmers have limited access to new chemical technologies compared to some of our larger competitors making the issue of weed resistance an ongoing concern.

In 2017 the EU banned 62 per cent of pesticides currently in use based mainly on environmental concerns of consumers, which is also having a flow on effect in Australia. ***(From the GRDC Grains Research Update, Wagga Wagga 2017).***

The adoption of new herbicide application and non-chemical technologies will set the foundations for Australian growers to remain internationally competitive, while protecting and expanding our export markets into the future.

Acknowledgements

- Independent Consultants Australia Network - (ICAN), GRDC, James Hunt, John Kirkegaard, Barry Haskins, Colin McMaster, Ian Menz, Neroli Brennan, Wes Greig, Ian Luelf, Agriculture Victoria. Bill Gordon (NuFarm).

This guideline has been developed by Central West Farming Systems Inc. (CWFS) as part of the Maintaining Profitable Farming Systems with Retained Stubble initiative, funded by the Grains Research and Development Corporation (GRDC). The initiative involves farming systems groups in Victoria, South Australia, southern and central New South Wales and Tasmania collaborating to validate current research at a local level and address issues for growers that impact the profitability of cropping systems with stubble; including pests, diseases, weeds, nutrition and the physical aspects of sowing and establishing crops in heavy residues.

During 2012 discussions with local producers resulted in CWFS identifying 13 subjects that impact on the management decisions for producers in Central West NSW.

Since then CWFS has undertaken a range of research, development and extension (RD&E) activities focusing on these subjects. These publications are an attempt to capture those activities and provide regionally specific guidelines for producers aiming to retain stubble in Central West NSW.

A primary part of this work has been to correlate existing resources and research from several organisations and CWFS thanks these respective organisations for their work. CWFS and the GRDC also thank the experts who technically reviewed these guidelines.

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