

# PRE-EMERGENT HERBICIDES FACT SHEET

## NORTHERN, SOUTHERN AND WESTERN REGIONS

### UNDERSTANDING PRE-EMERGENT HERBICIDES AND HOW THEY INTERACT WITH THE ENVIRONMENT

With the continued evolution of herbicide resistance, growers are being forced to introduce a range of different weed control tactics. A tactic that has rapidly increased in recent seasons is the use of pre-emergent herbicides, especially in the summer crop and fallow. To predict field performance of these herbicides, an understanding is needed of their chemical properties and how they interact with the environment.



*The presence of stubble or existing vegetation can intercept herbicide before it reaches the soil surface.*

#### KEY POINTS

- ▶ Knowing which weeds are in the paddock and where the weed seeds are located (shallow or deep) is important in selecting a herbicide to be applied.
- ▶ Be aware of whether a herbicide is subject to volatilisation or photodegradation in order to determine an incorporation strategy that minimises loss to the environment.
- ▶ Solubility influences how much rain is required for herbicide incorporation, how easily a herbicide will be taken up by a germinating weed and crop, and if a herbicide will be subject to moving down the profile, potentially causing crop injury or loss to leaching.
- ▶ Sandy or low organic matter soils will have less binding and allow for greater herbicide availability for crop and weed uptake.
- ▶ Herbicides that bind tightly to soil and organic matter generally require higher application rates, stay close to where they are applied (unless the soil moves), and persist for longer.
- ▶ Soil pH affects how long some herbicides persist for and how available they are for plant uptake and soil binding.
- ▶ The persistence of a herbicide and the way in which it breaks down will dictate the length of residual control and plantback constraints to sensitive crops.
- ▶ Rainfall after application is important for incorporation and availability to the weeds and crop. Rainfall and temperature also affect degradation.
- ▶ Choice of application rate will affect length of residual, and possibly crop selectivity.

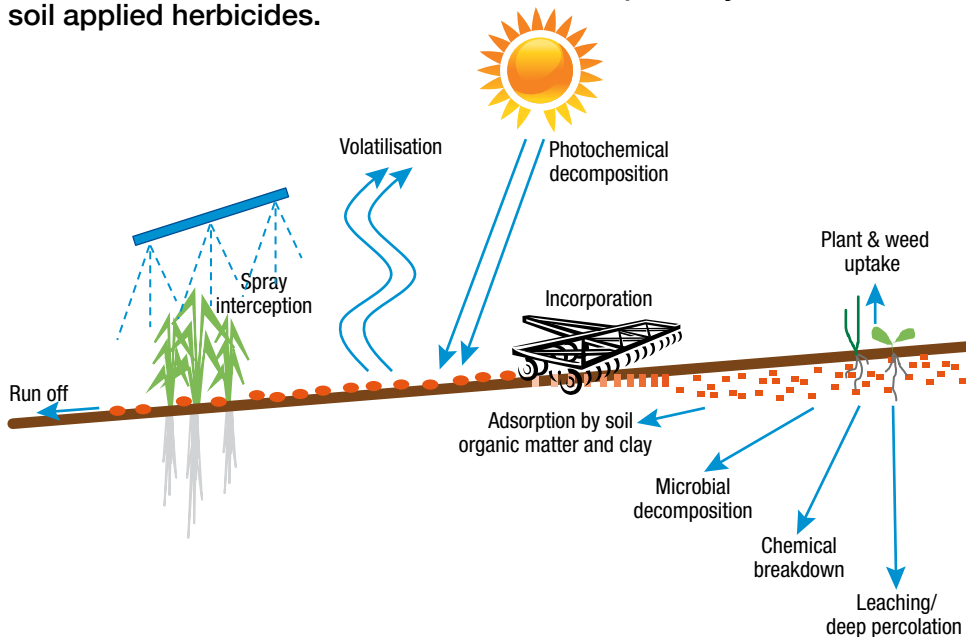
#### The value of pre-emergent herbicides

When devising a weed control strategy, consider the use of pre-emergent herbicides as an additional tactic available to help drive weed numbers down. Used alone they usually will not achieve the objective of driving down weed seedbank numbers, but when used amongst a suite of tactics, they can be particularly effective.

#### Pre-emergent herbicides:

- ▶ offer an alternate mode of action to many post-emergent options;
- ▶ can reduce selection pressure on subsequent post-emergent herbicide applications;
- ▶ remove much of the early season weed competitive pressure on a crop and can protect yield better than post-emergents, especially in weedy paddocks;
- ▶ can save costs, especially in the fallow where multiple knockdown applications may be required;
- ▶ can reduce the time pressure on spraying operations, especially in situations when double knocking is a requirement;
- ▶ have a major role to play in patch eradication where a weed blow-out can be GPS logged and a pre-emergent herbicide can be applied to manage the patch;

**FIGURE 1** Interactions, loss and breakdown pathways of soil applied herbicides.



- can be applied after the last cultivation to manage the few weed emergences that would otherwise be allowed to grow and return seed to the soil after a cultivation event is undertaken; and
- are useful in crops where there is a lack of post-emergent options, such as grass weed control in sorghum or broadleaf weed control in pulses.

### Factors influencing the activity of pre-emergent herbicides

To understand how pre-emergent herbicides will perform, it is important to understand the properties of the molecule and the soil type and how they interact and are broken down in the environment.



*Well-timed pre-emergent herbicides can provide season long control.*

Availability of a pre-emergent herbicide is an interaction between the solubility of the herbicide, the strength of binding onto soil colloids and organic matter, the prevailing climatic conditions, the environment, and the rate of herbicide applied.

### Stubble and crop interception

The presence of stubble or existing vegetation can intercept herbicide before it reaches the soil surface. This can have two negative effects:

- the herbicide tied up on the stubble or in the crop canopy may not be available for soil incorporation and subsequent weed control; and
- the existing standing organic material may result in an uneven coverage of the soil surface and so may result in areas with insufficient herbicide coverage, resulting in weed escapes.

Herbicide tie-up on stubble and plant material depends upon the herbicide solubility and the strength of binding to organic matter. Depending upon the molecule involved, the herbicide may be tightly bound and hence lost to the system in terms of weed control despite subsequent rainfall (for example trifluralin).

By comparison, a product that is loosely bound and soluble can be washed off stubble and into the soil by rainfall (for example chlorsulfuron).

Where high levels of stubble or plant material exist, the level of spray droplet interception can be reduced by alterations to how herbicide is applied. Some techniques that

could result in an increased proportion of herbicide getting to the soil include:

- winds across the rows;
- application speed less than 16km/h;
- use angled (rear facing) nozzles where the angle offsets the travel speed to have droplets moving predominantly downwards through the stubble;
- large droplets travelling at higher speed. Narrow fan angles (e.g. 65-80 degree) increase droplet speed;
- keeping water rates high to increase the number of droplets produced;
- narrower nozzle spacing (25cm vs 50cm); and
- minimising boom height, but ensuring at least double overlap.

In situations where pre-emergent herbicides are desired to be used in-crop, then directed spray set-up (layby application) can be used to minimise crop canopy interception.

### Photodegradation

Photodegradation occurs when a herbicide undergoes a chemical reaction in the presence of sunlight, becoming broken down and lost to the weed control system. For most pre-emergent herbicides used in Australian farming systems, photodegradation is not a major path of breakdown as standard incorporation practices such as cultivation, planting or adequate rainfall after application are typically adequate to prevent unacceptable losses. However, when a herbicide is sprayed onto the soil surface in summer with no following rainfall or mechanical incorporation, losses from this pathway will be at their highest.

Some of the common herbicides that can undergo some level of photodegradation include: the Group C herbicides atrazine, fluometuron, simazine, terbutylazine and diuron; sulfosulfuron; pendimethalin; picloram; and s-metolachlor.

If these herbicides are applied under warm, dry conditions with no rainfall expected in the coming weeks then mechanical incorporation should be considered to reduce losses to photodegradation.

### Volatilisation

Some of the pre-emergent herbicides used in the Australian grains industry are considered volatile. This means they will transition to a gaseous phase after application if left on the exposed soil surface without incorporation. Therefore

**TABLE 1 Vapour pressure for selected pre-emergent herbicides and summary of incorporation requirements.**

Herbicide (example)	Vapour pressure (mPa @ 25°C) <sup>^</sup>	
tri-allate (Avadex <sup>®</sup> )	12	Actives with a vapour pressure of greater than 1mPa are generally considered volatile and are likely to require incorporation. Refer to individual product labels for specific situations.
trifluralin (Treflan <sup>®</sup> )	9.5	
s-metolachlor (Dual <sup>®</sup> Gold)	3.7	
dimethenamid-P (Outlook <sup>®</sup> )	2.5	
pendimethalin (Stomp <sup>®</sup> )	1.94	
clopyralid (Lontrel <sup>®</sup> )	1.36	
prosofocarb (Boxer <sup>®</sup> Gold <sup>p</sup> )	0.79	Actives with a vapour pressure of less than 1mPa are generally considered non-volatile and do not usually require any specific incorporation recommendations after application.
metribuzin (Sencor <sup>®</sup> )	0.121	
terbuthylazine (Terbyne <sup>®</sup> )	0.12	
propyzamide (Kerb <sup>®</sup> )	0.03	
imazapic (Flame <sup>®</sup> )	0.01	
atrazine (Gesaprim <sup>®</sup> )	0.0039	
triasulfuron (Logran <sup>®</sup> )	0.0021	
isoxaflutole (Balance <sup>®</sup> )	1.0 x 10 <sup>-3</sup>	
diuron (various)	1.15 x 10 <sup>-3</sup>	
pyroxasulfone (Sakura <sup>®</sup> )	2.4 x 10 <sup>-3</sup>	
diflufenican (Brodal <sup>®</sup> )	4.25 x 10 <sup>-3</sup>	
picloram (Tordon <sup>®</sup> )	8.0 x 10 <sup>-5</sup>	
chlorsulfuron (Glean <sup>®</sup> )	3.07 x 10 <sup>-6</sup>	

<sup>^</sup> (University of Hertfordshire, 2006-2014) The Pesticide Properties DataBase (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire. Accessed on 4th August 2014 <http://sitem.herts.ac.uk/aeru/iupac/index.htm>

<sup>p</sup> Vapour pressure of prosofocarb. Boxer<sup>®</sup> Gold also contains s-metolachlor

these products must be incorporated soon after application to avoid significant losses to the atmosphere and reduced level of weed control.

The volatility of a herbicide is determined by its vapour pressure. Molecules with a high vapour pressure will convert rapidly into a gaseous phase and be lost.

## Incorporation

Without incorporation some herbicides are more predisposed to breakdown and loss from volatilisation and photodegradation.

In situations where incorporation is advisable, 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 still keeping it in the zone required for weed control (which is often close to the soil surface for shallow germinating weeds).

If using cultivation or incorporation by sowing (IBS), target incorporation at 2 to 5 centimetres for most herbicides. If rainfall or irrigation is used to incorporate the herbicide, wet the soil to a depth of 3 to 4cm. Excessive rainfall or irrigation can move some herbicides through the profile before the compound has a chance to bind to the soil colloids and organic matter, especially in sandy or low organic matter soils.

This can result in the herbicide moving below the germinating zone of the weeds, resulting in poor weed control, and may also potentially increase crop injury where the herbicide comes into close contact with the germinating crop.

**TABLE 2 Solubility of selected pre-emergent herbicides.**

Herbicide (example)	Solubility (mg/L @ 20°C) <sup>^</sup>	
diflufenican (Brodal <sup>®</sup> )	0.05	Low solubility (0 to 49mg/L @20°C). Likely to require moist conditions for incorporation and uptake.
trifluralin (Treflan <sup>®</sup> )	0.22	
pendimethalin (Stomp <sup>®</sup> )	0.33	
pyroxasulfone (Sakura <sup>®</sup> )	3.5	
tri-allate (Avadex <sup>®</sup> )	4	
simazine (Gesatop <sup>®</sup> )	5	
isoxaflutole (Balance <sup>®</sup> )	6	
terbuthylazine (Terbyne <sup>®</sup> )	7	
prosofocarb (Boxer <sup>®</sup> Gold <sup>p</sup> )	13	
atrazine (Gesaprim <sup>®</sup> )	30	
diuron (various)	36	Moderate solubility (50 to 500mg/L @20°C).
s-metolachlor (Dual <sup>®</sup> Gold)	480	
picloram (Tordon <sup>®</sup> )	560	
triasulfuron (Logran <sup>®</sup> )	815	
metribuzin (Sencor <sup>®</sup> )	1165	
dimethenamid-P (Outlook <sup>®</sup> )	1450	
imazapic (Flame <sup>®</sup> )	2230	
chlorsulfuron (Glean <sup>®</sup> )	12,500	
clopyralid (Lontrel <sup>®</sup> )	143,000	

<sup>^</sup> (University of Hertfordshire, 2006-2014) The Pesticide Properties DataBase (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, Accessed on 4th August 2014 <http://sitem.herts.ac.uk/aeru/iupac/index.htm>

<sup>p</sup> Solubility of prosofocarb. Boxer<sup>®</sup> Gold also contains s-metolachlor

## Solubility

Many pre-emergent herbicides are taken up by the roots of the germinating weed. For root uptake to occur, the herbicide needs to be available in the soil moisture. If the soil is dry, there is little herbicide in the soil water that is available for root uptake. This is why many pre-emergent herbicides may fail to provide good weed control under dry conditions.

Herbicides with low solubility often require larger volumes of rainfall to achieve incorporation and tend not to remain as available in the soil moisture, so they are not easily taken up by plant roots. Typically, they need very good moisture conditions after application, and for the period of desired weed control, for effective performance.

Conversely, herbicides with high solubility are relatively easy to incorporate with limited rainfall and generally prefer to remain in the soil moisture phase, so they are 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, so is more likely to leach or cause off-target effects.

Once in the soil, the herbicide will establish equilibrium between the available soil water and binding onto soil colloids. It typically takes a couple of days for this equilibrium to establish following incorporating rainfall.

For this reason, most new herbicide labels, and those older products undergoing revision, will generally have a constraint to the effect of 'Do not irrigate' or 'Do not apply if runoff rainfall is expected within 2 or 3 days'. This is, in part, to allow time for binding onto soil and organic matter to occur. Even herbicides that generally bind relatively tightly can still be lost if high intensity rainfall leading to runoff or deep percolation occurs as the first incorporating event.

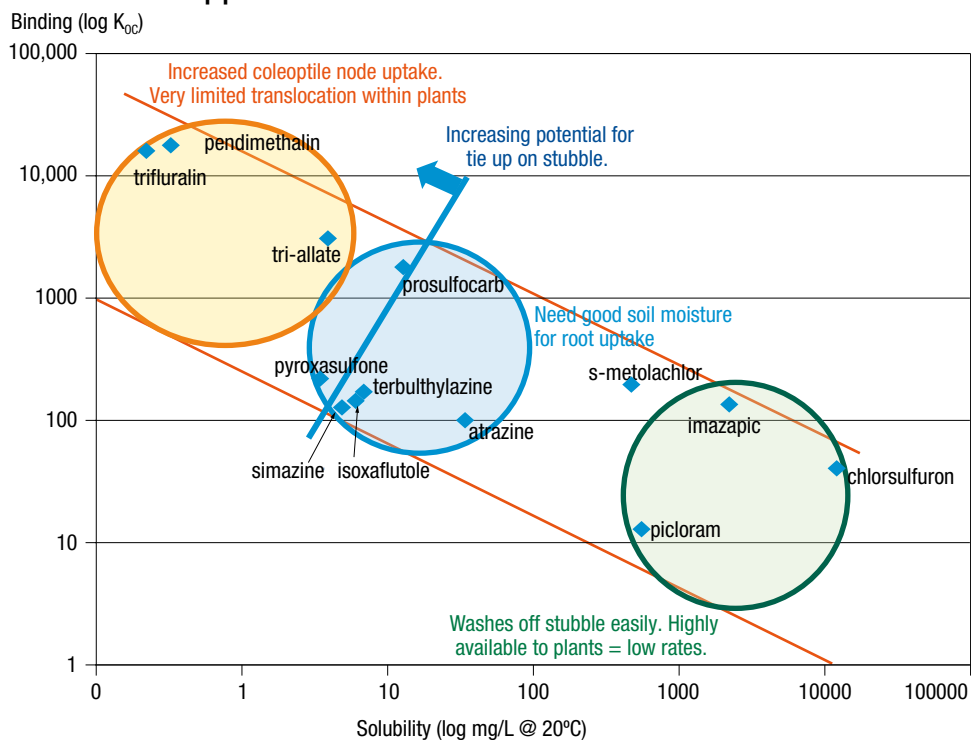
### Position of the herbicide in the soil

The germination zone of target weeds is important to understand. In a zero till environment it is likely that over time the weed spectrum will become dominated by surface or very shallow germinating weeds.

Large seeded weeds, that are better adapted to germination from depth, are likely to become less important. Therefore, in a zero till system, it is most likely that the pre-emergent herbicide will need to bind and stay relatively close to the soil surface in the zone where the weed seeds are germinating.

Conversely, if deeper germinating weeds are the target, then having a herbicide which stays bound to the soil surface may

**FIGURE 2 Interactions between solubility and binding of selected soil applied herbicides.**



allow for weeds to germinate at depth and grow through the herbicide band on the soil surface.

### Soil texture, cation exchange and binding

Soil texture (the ratio of sand, silt and clay) and soil organic matter will have an

effect on the binding ability of herbicides (adsorption). The term cation exchange capacity (CEC) is often used as a measure of the soil's adsorption sites.

Heavier soils and those soils with higher amounts of organic matter (higher CEC soils) have more binding sites and hence will adsorb more herbicide. Increased binding is likely to result with higher application rates being required to achieve a given level of weed control. This is because more herbicide is bound to soil and organic matter and therefore less is available in the soil water for uptake by germinating weeds. Increased binding also generally results in less leaching.

The strength of binding is measured by the Soil/Water Absorption Coefficient ( $K_d$ ) which is the ratio of herbicide bound to the soil to that in the soil water. As binding is often highly influenced by the level of organic matter, the binding coefficient is often normalised to take into account organic carbon levels in different soils and is presented as a Soil Organic Carbon-Water Absorption Coefficient ( $K_{oc}$ ) value.

For some molecules the  $K_{oc}$  is very sensitive to soil pH, in particular the imidazolinone herbicides which bind tighter at acidic (low) pH, making them less available for plant uptake and for microbial breakdown.

Comparing solubility and binding of selected pre-emergent herbicides (see Figure 2) highlights trends that can help in understanding how these molecules are likely to perform.

**TABLE 3 Average adsorption coefficients for selected pre-emergent herbicides.**

Herbicide (example)	Average $K_{oc}$ value <sup>^</sup>		
pendimethalin (Stomp <sup>®</sup> )	17581	$K_{oc} > 4000$ Non-mobile.	Likely to bind tightly to soil and organic matter.
trifluralin (Treflan <sup>®</sup> )	15800		
tri-allate (Avadex <sup>®</sup> )	3,034		
diflufenican (Brodal)	1622-2369 <sup>#</sup>	$K_{oc}$ 500 to 4000 Slightly mobile.	
prosulfocarb (Boxer <sup>®</sup> Gold <sup>®</sup> )	1367-2340 <sup>#</sup>		
diuron (various)	813	$K_{oc}$ 75 to 500 Moderately mobile.	Likely to move with soil water.
terbutylazine (Terbyne <sup>®</sup> )	230 <sup>@1</sup>		
dimethenamid-P (Outlook <sup>®</sup> )	218 <sup>@1</sup>		
s-metolachlor (Dual <sup>®</sup> Gold)	200 <sup>#</sup>		
isoxaflutole (Balance <sup>®</sup> )	145		
imazapic (Flame <sup>®</sup> )	137		
simazine (Gesatop <sup>®</sup> )	130		
atrazine (Gesaprim <sup>®</sup> )	100		
pyroxasulfone (Sakura <sup>®</sup> )	95 <sup>@2</sup>		
metribuzin (Sencor <sup>®</sup> )	60 <sup>@1</sup>		
triasulfuron (Logran <sup>®</sup> )	60	$K_{oc}$ 15 to 75 Mobile.	
chlorsulfuron (Glean <sup>®</sup> )	40 <sup>@1</sup>		
picloram (Tordon <sup>®</sup> )	13 <sup>@1</sup>	$K_{oc}$ 0 to 15 Very mobile	
clopyralid (Lontrel <sup>®</sup> )	5		

<sup>^</sup> (University of Hertfordshire, 2006-2014) The Pesticide Properties DataBase (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire. Accessed on 4th August 2014 <http://sitem.herts.ac.uk/aeru/iupac/index.htm>

<sup>#</sup> (Senseman, 2007) Herbicide Handbook (2007) Weed Society of America

<sup>@1</sup>(USDA Natural Resources Conservation Service) Windows Pesticide Screening Tool

<sup>@2</sup>(APVMA, 2011) Evaluation of the New Active Pyroxasulfone in the Product Sakura<sup>®</sup> 850 WG Herbicide

p  $K_{oc}$  of prosulfocarb. Boxer<sup>®</sup> Gold also contains s-metolachlor

**TABLE 4 Average DT<sub>50</sub> values for selected pre-emergent herbicides.**

Herbicide (example)	Average DT <sub>50</sub> value <sup>^</sup>		
dimethenamid-P (Outlook <sup>®</sup> )	7 (2-16)	DT <sub>50</sub> 0 to 30 Non-persistent	Unlikely to have plant back constraints the following year. Likely to move with soil water.
prosofocarb (Boxer <sup>®</sup> Gold <sup>®</sup> )	10 (7-13)		
s-metolachlor (Dual <sup>®</sup> Gold)	15 (11-31)		
metribuzin (Sencor <sup>®</sup> )	14-28		
triasulfuron (Logran <sup>®</sup> )	19 (3-48)		
pyroxasulfone (Sakura <sup>®</sup> )	22 (16-26)		
terbuthylazine (Terbyne <sup>®</sup> )	22 (10-36)		
picloram (Tordon <sup>®</sup> )	36 (20-49)	DT <sub>50</sub> 30 to 100 Moderate	Plant back constraints will occur.
chlorsulfuron (Glean <sup>®</sup> )	36 (11-70)		
clopyralid (Lontrel <sup>®</sup> )	40 (12-70) <sup>#</sup>		
tri-allate (Avadex <sup>®</sup> )	46 (8-205)		
atrazine (Gesaprim <sup>®</sup> )	60 <sup>@1</sup> (6-108)		
diuron (various)	89 (20-231)		
simazine (Gesatop <sup>®</sup> )	90		
pendimethalin (Stomp <sup>®</sup> )	90 (27-186)	DT <sub>50</sub> >100 Persistent	Long re-cropping intervals will exist to sensitive crops.
trifluralin (Treflan <sup>®</sup> )	170 (35-375)		
diflufenican (Brodal <sup>®</sup> )	180		
imazapic (Flame <sup>®</sup> )	232 (31-410)		

<sup>^</sup> (University of Hertfordshire, 2006-2014) The Pesticide Properties DataBase (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire. Accessed on 4th August 2014 <http://sitem.herts.ac.uk/aeru/iupac/index.htm>

<sup>#</sup> (Senseman, 2007) Herbicide Handbook (2007) Weed Society of America

<sup>@1</sup> (USDA Natural Resources Conservation Service) Windows Pesticide Screening Tool

<sup>p</sup> DT50 of prosofocarb. Boxer<sup>®</sup>Gold also contains s-metolachlor

## Breakdown

Once in the soil, herbicide breakdown typically occurs via microbial degradation or chemical reaction (hydrolysis).

For many herbicides, microbial degradation is the primary path of degradation.

Conditions which encourage soil microbes (warmer temperature, good soil moisture, adequate oxygen and nutrients, neutral pH) will typically see faster degradation, and hence less persistence of the herbicide.

Extended dry periods can substantially increase the persistence of these herbicides.

For herbicides that breakdown via hydrolysis, the speed of this breakdown is influenced by temperature and moisture and may be influenced by pH. For example, triazines (Group C) and sulfonyleureas (Group B) typically undergo chemical hydrolysis as the primary method of breakdown in neutral or acid soils. However, the speed of this reaction decreases (or ceases) as pH increases. Breakdown then happens via slower microbial degradation meaning these herbicides persist much longer in alkaline soils.

As a herbicide is broken down, the equilibrium between the herbicide in the soil and the water phase will remain in the same ratio. Typically this means that some

of the herbicide bound to the soil particles will be gradually released back into the soil water as the herbicide in the water phase is either broken down, lost to leaching or taken up by plants.

## Persistence

The rate of herbicide persistence is usually reported as a DT<sub>50</sub> value. The DT<sub>50</sub> value is a half-life, or the days of time that it takes for 50 per cent of the herbicide in the soil to breakdown.

How long a molecule remains in the soil depends upon the soil type (binding), speed and type of breakdown, and application rate. The rate of breakdown varies between different soils and environmental conditions, so the DT<sub>50</sub> is often reported as a range of values, or an average, or both.

## Rotational crop constraints (plantbacks)

By definition, all pre-emergent herbicides, even those classified as non-persistent, will have some level of plant-back constraint to the most susceptible species.

**ALWAYS check and follow the rotational crop advice on the product label.**

Products that rely on microbial breakdown for degradation require an environment

where soil organisms are active for prolonged periods of time.

As a biological process, it takes time with good soil conditions for a microbial population to build – a process that is unlikely to occur under dry soil conditions. The amount of total rainfall is often less important to microbial breakdown than how long the topsoil, which contains most of the microbes and herbicide, is wet for.

Product labels are designed to cater for these situations and should be followed. In borderline situations, the following strategies may provide additional data on which to assess or reduce risk.

- Soil testing may be possible from a laboratory specialising in herbicide residue testing. However, this can be time consuming and expensive and testing may not be available for all molecules. Additionally, test results will only reveal the quantity of herbicide remaining in the soil. If levels of herbicide are detected, interpretation will be required to understand if this level will prevent establishment of the desired crop.

- A simple bioassay can be conducted whereby seeds of the desired crop are planted into the field a few weeks prior to the desired planting date and establishment is observed to understand the level of crop injury. This can give a quick indication of the likelihood of any residues affecting germination. However, care must be taken, especially with herbicides which are more mobile and may have moved down the soil profile. In this situation, germination may be unaffected, however, severe damage or plant death could still result when the roots of the new crop extend into the residual herbicide layer further down the profile. Also, some herbicides at sub-lethal doses may not greatly affect germination, but may provide a significant biomass reduction after emergence. As such, germination tests can provide false confidence.

- For herbicides that are tightly bound to the soil surface, aggressive cultivation prior to planting of a sensitive crop may dilute the remaining herbicide throughout the soil profile and allow improved crop establishment, however, this is a risky process to rely on.

- Switch to a crop variety or crop type that is tolerant to the expected herbicide residue.

## Crop safety

Selectivity of grain crops planted pre or post application of a pre-emergent herbicide is an important consideration. The emerging crop will also be exposed to the pre-emergent herbicide which may lead to observable crop effects.

There are a number of strategies that promote acceptable crop tolerance.

### Crop tolerance

Some crops are inherently more tolerant to a particular herbicide. Usually this tolerance comes from the crop being able to rapidly detoxify that herbicide. There may also be differences between individual varieties in their ability to detoxify a particular herbicide.

In some situations a herbicide safener can be used to further accelerate the crop's ability to metabolise the herbicide. A good example of this is the application of Concep® II to sorghum seed to accelerate the metabolism of s-metolachlor.

Some crop varieties have been bred to include tolerance to specific herbicides, for example, Clearfield® varieties demonstrate tolerance to imidazolinone herbicides. This both enables the use of a different herbicide in those crops and provides rotational options in the event of a residual being present.

### Differential placement

If the herbicide has properties that cause it to bind to the soil surface then it may be

able to be used in a situation where the crop is planted at a depth well below the herbicide band, and therefore the crop roots grow in soil without herbicide residues.

While this may be an effective strategy in certain situations, crop injury may still occur in situations where the first rainfall event is large and the herbicide is moved down to the crop seed zone.

This strategy may not be acceptable for all products and soil types, for example in sandy soils or those low in organic matter (low cation exchange capacity), as lack of binding may still result in herbicide coming into contact with the germinating crop.

### Physical removal of herbicide in the furrow

The incorporation by sowing (IBS) technique used in conjunction with knife point seeders can achieve adequate selectivity by physically removing the treated soil directly above the furrow and throwing this into the interrow, leaving an untreated area through which the crop can emerge.

Careful attention to planting set up is required to ensure seed is placed in the area without herbicide and treated soil is not thrown into adjoining crop rows. Press wheels are generally required to ensure treated soil does not fall back into the furrow. Heavy rainfall after application can still cause problems if treated soil is washed into the furrow.



*Waterlogging in combination with pre-emergent herbicides may sometimes result in crop injury.*

Regardless of the strategy employed, there may be times when an adverse crop effect is still observed. This often occurs when crop placement and environmental conditions allow some herbicide/crop contact – often coinciding with the emerging seedling being under an additional stress that slows the rate of metabolism, reducing the crop's ability to detoxify the herbicide.

This is frequently observed in situations of waterlogging or prolonged cold or frost.

## MORE INFORMATION

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## PROJECT CODE

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## USEFUL RESOURCES

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