PRE-EMERGENT HERBICIDES
FACT SHEET

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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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. One of these tactics that has rapidly increased in recent seasons is the use of pre-emergent herbicides. To predict field performance of these herbicides, an understanding of their chemical properties and how they interact with the environment is needed.

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 of efficacy due to leaching.
- Sandy or low organic matter soils will have less binding and allow for greater herbicide availability for crop and weed uptake. Herbicides will also be more easily lost due to leaching.
- 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 often persist for longer.
- Soil pH may affect how long some herbicides persist 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 presence of stubble or existing vegetation can intercept herbicide before it reaches the soil surface.

The value of pre-emergent herbicides

When devising a weed control strategy, consider the use of pre-emergent herbicides as an additional tactic 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;
- 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; 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 how the herbicide is broken down in the environment.

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:

1. the herbicide tied up on the stubble or in the crop canopy may not be available for soil incorporation and subsequent weed control; and
2. organic matter (stubble or weeds) 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:

- wind across the rows;
- application speed less than 16km/h;
- large droplets travelling at higher speed. Narrow fan angles (e.g. 65-80 degree) increase droplet speed;
- when using large droplets use angled (rear facing) nozzles where the angle offsets the travel speed to have droplets moving predominantly downwards through the stubble;
- 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.

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

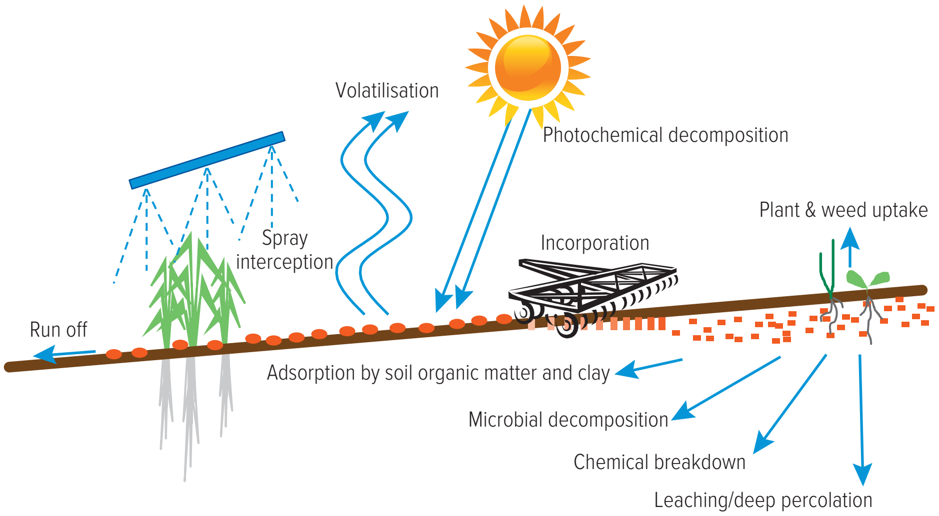

TABLE 1 Vapour pressure for common pre-emergent herbicides and summary of incorporation requirements.

Herbicide (example)	Vapour pressure (mPa @ 20 to 25°C)^	
tri-allate (Avadex®)	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®)	9.5	
cinmethylin (Luximax®)	8.1[@1]	
s-metolachlor (Dual®)	3.7	
pendimethalin (Stomp®)	3.34	
bixlozone (Overwatch®)	2.3[@2]	
clopyralid (Lontrel®)	1.36[#]	
prosulfocarb (Arcade®)	0.79	Actives with a vapour pressure of less than 1mPa are generally considered non-volatile and do not usually require any specific incorporation after application.
flumioxazin (Terrain®)	0.32	
napropamide (Devrinol®)	0.22	
terbuthylazine (Terbyne®)	0.152	
metribuzin (Sencor®)	0.121	
metazachlor (Butisan®)	0.093	
propyzamide (Rustler®)	0.058	
atrazine (Gesaprim®)	0.039	
imazapic (Flame®)	0.01	
triasulfuron (Logran®)	0.0021	
carbetamide (Ultro®)	0.0003	
mesotrione (Callisto®)	5.7 x 10^{-3}	
diflufenican (Brodal®)	4.25 x 10^{-3}	
fomesafen (Reflex®)	4.0 x 10^{-3}	
pyroxasulfone (Sakura®)	2.4 x 10^{-3}	
diuron (various)	1.15 x 10^{-3}	
simazine (Gesatop)	8.1 x 10^{-4}	
picloram (Tordon®)	8.0 x 10^{-5}	
isoxaflutole (Balance®)	3.22 x 10^{-5}	
chlorsulfuron (various)	3.07 x 10^{-6}	
trifludimoxazin (Voraxor®)	1.1 x 10^{-7}[B]	
saflufenacil (Voraxor®)	4.5 x 10^{-12}	

TABLE 2 Solubility of common pre-emergent herbicides.

Herbicide (example)	Solubility (mg/L @ 20°C)^	
diflufenican (Brodal®)	0.05	Low solubility (0 to 49mg/L @ 20°C). Likely to require moist conditions for incorporation and uptake.
trifluralin (Treflan®)	0.22	
pendimethalin (Stomp®)	0.33	
flumioxazin (Terrain®)	0.8	
trifludimoxazin (Voraxor®)	1.78[B]	
pyroxasulfone (Sakura®)	3.5	
tri-allate (Avadex®)	4	
simazine (Gesatop®)	5	
isoxaflutole (Balance®)	6*	
terbuthylazine (Terbyne®)	7	
propyzamide (Rustler®)	9	
prosulfocarb (Arcade®)	13	
atrazine (Gesaprim®)	35	
diuron (various)	36	
bixlozone (Overwatch®)	40[@2]	
fomesafen (Reflex®)	50	Moderate solubility (50 to 500mg/L @ 20°C).
cinmethylin (Luximax®)	63[@2]	
napropamide (Devrinol®)	74	
metazachlor (Butisan®)	450	
s-metolachlor (Dual®)	480	
picloram (Tordon®)	560	High solubility (> 501mg/L @ 20°C).
triasulfuron (Logran®)	815	
metribuzin (Sencor®)	1100[#]	
mesotrione (Callisto®)	1500	
saflufenacil (Voraxor®)	2100	
imazapic (Flame®)	2 230	
carbetamide (Ultro®)	3270	
clopyralid (Lontrel®)	7 850	
chlorsulfuron (various®)	12 500	

^ (University of Hertfordshire, 2006-2019) The Pesticide Properties DataBase (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire. Accessed on 2nd October 2019. http://sitem.herts.ac.uk/aeru/iupac/index.htm

[#] (Shaner. D, 2014) Herbicide Handbook (2014) Weed Society of America

* However the active metabolite (DKN) is highly soluble

[@1] (APVMA, 2019) Public release summary on the evaluation of the new active cinmethylin in the product Luximax® herbicide

[@2] (APVMA, 2019) Public release summary on the evaluation of the new active bixlozone in the product Overwatch® herbicide

[B] https://apvma.gov.au/sites/default/files/publication/65676-prs_on_trifludimoxazin_in_the_product_voraxor_herbicide.pdf

Photodegradation

Photodegradation occurs when a herbicide undergoes a chemical reaction in the presence of sunlight.

As a result, some herbicide may be lost prior to incorporation. 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 5 (C) herbicides atrazine, fluometuron, simazine, terbuthylazine and diuron; sulfosulfuron; pendimethalin; picloram; napropamide; and s-metolachlor.

If these herbicides are applied under warm, dry conditions with

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

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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 may experience a level of volatilisation loss under certain environmental conditions. This means they will transition to a gaseous phase after application if left on the soil surface without incorporation. Therefore these products must be incorporated soon after application to avoid significant losses to the atmosphere and reduced level of weed control.

The vapour pressure of a herbicide (see Table 1) gives some relativity between herbicides with regard to the potential speed of loss. Herbicides with higher vapour pressure will require more urgency of incorporation. The actual rate of loss will depend on the environmental conditions following application and the surface where the herbicide has been deposited.

Fastest loss will occur when temperature is higher and there is a wind blowing across the surface.

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.

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 (see Table 2) 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. For effective performance, they typically need very good moisture conditions after application and for the period of desired control.

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.

TABLE 3 Average adsorption coefficients for common pre-emergent herbicides.

Herbicide (example)	Average K_{oc} value^		
pendimethalin (Stomp®)	17 491	K_{oc} > 4000 Non-mobile.	Likely to bind tightly to soil and organic matter.
trifluralin (Treflan®)	15 800		
tri-allate (Avadex®)	3 034	K_{oc} 500 to 4000 Slightly mobile.	
diflufenican (Brodal®)	1 622-2 369[#]		
prosulfocarb (Arcade®)	1 367-2 340[#]		
flumioxazin (Terrain®)	889		
propyzamide (Rustler®)	840		
napropamide (Devrinol®)	839		
diuron (various)	680		
trifludimoxazin (Voraxor®)	436[BC]	K_{oc} 75 to 500 Moderately mobile.	Likely to move with soil water.
terbuthylazine (Terbyne®)	230[@3]		
cinmethylin (Luximax®)	373[@1]		
bixlozone (Overwatch®)	334-465[@2]		
pyroxasulfone (Sakura®)	223		
s-metolachlor (Dual®)	200[#]		
isoxaflutole (Balance®)	145		
imazapic (Flame®)	137		
simazine (Gesatop®)	130		
mesotrione (Callisto®)	122		
atrazine (Gesaprim®)	100		
carbetamide (Ultro®)	88.6[C]		
metribuzin (Sencor®)	60[#]	K_{oc} 15 to 75 Mobile.	
triasulfuron (Logran®)	60		
metazachlor (Butisan®)	54		
fomesafen (Reflex®)	50		
chlorsulfuron (various)	40[#]		
picloram (Tordon®)	13[#]	K_{oc} 0 to 15 Very mobile.	
saflufenacil (Voraxor®)	9-56[#]		
clopyralid (Lontrel®)	5		

TABLE 4 Average DT_{50}* values for common pre-emergent herbicides.

Herbicide (example)	Average (range) DT_{50} value^		
mesotrione (Callisto®)	5 (3-14)[@4]	DT_{50} 0 to 30 Non-persistent	Unlikely to have plant back constraints the following year. Likely to move with soil water.
metazachlor (Butisan®)	7 (3-21)		
prosulfocarb (Arcade®)	10 (7-13)		
carbetamide (Ultro®)	10 (8-12)		
trifludimoxazin (Voraxor®)	14[B]		
flumioxazin (Terrain®)	18 (16-20)		
metribuzin (Sencor®)	19 (14-28)[#]		
saflufenacil (Voraxor®)	20		
s-metolachlor (Dual®)	21 (11-31)		
pyroxasulfone (Sakura®)	22 (16-26)		
terbuthylazine (Terbyne®)	22 (16-149)		
chlorsulfuron (various)	36 (10-185)	DT_{50} 30 to 100 Moderate	Plant back constraints will occur.
triasulfuron (Logran®)	39 (16-92)		
clopyralid (Lontrel®)	40 (12-70)[#]		
tri-allate (Avadex®)	46 (8-205)		
cinmethylin (Luximax®)	59 (19-193)[@1]		
propyzamide (Rustler®)	60 (18-53)[#]		
atrazine (Gesaprim®)	60 (6-108)		
napropamide (Devrinol®)	72 (31-127)		
fomesafen (Reflex®)	86		
diuron (various)	90[#]		
picloram (Tordon®)	90 (20-300)[#]		
simazine (Gesatop®)	90 (27-102)		
bixlozone (Overwatch®)	93 (46-267)[@2]		
pendimethalin (Stomp®)	100 (40-187)	DT_{50} > 100 Persistent	Long re-cropping intervals will exist to sensitive crops
diflufenican (Brodal®)	(105-210)		
trifluralin (Treflan®)	170 (35-375)		
imazapic (Flame®)	232 (31-410)		

^ (University of Hertfordshire, 2006-2019) The Pesticide Properties DataBase (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire. Accessed on 2nd October 2019. http://sitem.herts.ac.uk/aeru/iupac/index.htm

*DT_{50} (half-life) The days of time for 50% of the herbicide to dissipate from the soil. Herbicides with longer DT_{50} values are likely to be more persistent

[#] (Shaner. D, 2014) Herbicide Handbook (2014) Weed Society of America

[@1] (APVMA, 2019) Public release summary on the evaluation of the new active cinmethylin in the product Luximax® herbicide

[@2] (APVMA, 2019) Public release summary on the evaluation of the new active bixlozone in the product Overwatch® herbicide

[@3] (USDA Natural Resources Conservation Service) Windows Pesticide Screening Tool

[@4] (APVMA, 2019) Public Release Summary on the evaluation of the new active mesotrione in the product Callisto® herbicide

K_{oc} (soil adsorption coefficient) The higher the K_{oc} value, the greater the propensity to bind to soil. Herbicide with higher K_{oc} values tend to be less mobile in the soil

[B] https://apvma.gov.au/sites/default/files/publication/65676-prs_on_trifludimoxazin_in_the_product_voraxor_herbicide.pdf

[C] Reported as Kfoc, makes no practical difference under field conditions

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.

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 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.

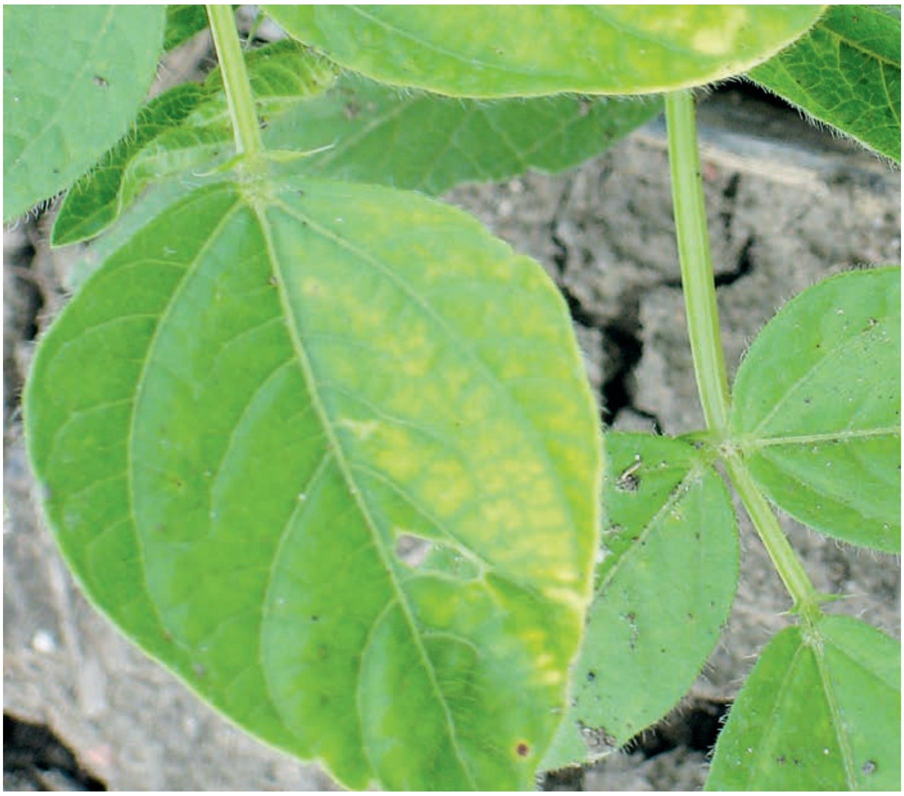
Heavier soils and soils with higher amounts of organic matter (higher CEC soils) have more binding sites and hence will adsorb more herbicide. Increased binding is likely to result in higher application rates being required to achieve a given level of weed control.

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 (Kd) 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 (see Table 3).

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.

Understanding both the solubility and soil binding assists in predicting the behaviour of a pre-emergent herbicide in the soil and environment (Figure 2).



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

Breakdown

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

For most herbicides, microbial degradation is the primary type of breakdown. 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.

Figure 2 Pre-emergent herbicide mobility in the soil is primarily influenced by solubility and binding.

TIGHT BINDING	RELATIVELY TIGHT BINDING	LOW MOBILITY	SOME MOBILITY	MOBILE
pendimethalin trifluralin	prosulfocarb tri-allate	diuron propyzamide flumioxazin napropamide	atrazine simazine terbuthylazine pyroxasulfone bixlozone cinmethylin	Group 2 (B) metribuzin mesotrione Group 4 (I) metazachlor s-metolachlor
Won't wash off stubble after spray has dried.	More difficult to wash off stubble after spray has dried.	Requires significant rainfall to remove from stubble.	Will wash off stubble with adequate rainfall.	Relatively easy to wash off stubble.
Suited to IBS (incorporate by sowing) with knife points and press wheels				Higher potential for crop damage

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 5 (C)) and sulfonylureas (Group 2 (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_{50} value. The DT_{50} 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_{50} is often reported as a range of values, or an average, or both (see Table 4).

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.

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.

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 will not 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, remians moist.

Product labels are designed to cater for these situations and should be followed.

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

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 herbicide is detected, then interpretation of the result will be required to determine the level of risk it may present to establishment of the desired crop. For mobile herbicides, testing at multiple soil depths will be required.
- 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 injury.

There are a number of strategies that promote increased crop safety.

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 these 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.

Regardless of the strategy employed, there may be times when crop injury 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.

Using pre-emergent herbicides after soil amelioration

Deep ripping or spading is designed to break up and mix the upper soil layers. Pay particular attention to furrow opening and closing when using pre-emergent herbicides. These practices may increase the risk of seeding furrow collapse, with herbicide-treated soil falling back on top of seed.

These tillage practices may also distribute some of the weed seeds deeper throughout the soil profile. IBS application with non-mobile herbicides is designed to be used in a zero till farming system, where the herbicide is positioned close to the soil surface where the weed seeds will be located. Following more aggressive tillage, weed seeds that germinate from deeper in the profile may not come into contact with sufficient concentration of herbicide and this can lead to poor weed control.

Full inversion tillage, using moldboard or one-way ploughs, is designed to place all the weed seeds at a depth from where they will not be able to emerge. Provided this is achieved, it may reduce the need for pre-emergent herbicides in the year following inversion tillage. However, if pre-emergent herbicides are used following inversion tillage they can often behave differently. There will be very low levels of organic matter and soil microbes at the soil surface following inversion tillage, which is likely to result in much greater herbicide availability and hence a greater risk of crop injury, especially on lighter soils. Conversely, if soil bought to the surface has a significantly higher clay content then it can be possible that more herbicide could be bound to this 'heavier' soil.

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.

MORE INFORMATION

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USEFUL RESOURCES

Congreve, M. and Cameron, J. (eds). (2019). **Soil Behaviour of Pre-emergent Herbicides in Australian Farming Systems – a reference for advisers** (2nd Edition). GRDC publication, Australia. www.grdc.com.au/SoilBehaviourPreEmergentHerbicides

Congreve, M. and Cameron, J. (eds) (2019). **Rotational crop constraints for herbicides used in Australian farming systems.** GRDC publication, Australia. https://grdc.com.au/rotational-crop-constraints-for-herbicides

WeedSmart (2019) Pre-emergent herbicides 101. WeedSmart Diversity Era, Australia. https://www.diversityera.com/courses/pre-emergent-herbicides-101

University of Hertfordshire. The **Pesticide Properties DataBase** (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2019. http://sitem.herts.ac.uk/aeru/iupac/

Herbicide Handbook. 10th Edition (2014). Weed Society of America.

Hall, L. Beckie, H. and Wolf, T. (2009). **How Herbicides Work – Biology to Application**. Government of Alberta.

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