PRE-EMERGENT HERBICIDES

Utilising pre-emergent herbicides in Central Queensland grains and cotton cropping systems.

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FACT SHEET APRIL 2024

INTRODUCTION

Pre-emergent (residual) herbicides are becoming increasingly important in weed control strategies in Central Queensland.

The increase in the number of weed populations that are resistant to post-emergent (knockdown) herbicides such as glyphosate, has resulted in fewer effective options for post-emergent weed control. Pre-emergent herbicides are a valuable additional tactic that can significantly reduce weed emergence. This reduces the weed numbers present when post-emergent herbicides are applied, and in turn reduces the risk of herbicide resistance developing as a problem in the system.

The variable climate in Central Queensland, e.g., heavy rainfall events and sometimes prolonged dry periods, can make it more challenging to fit pre-emergent herbicides into a summer and winter cropping system. However, with an understanding on the key factors that influence product efficacy and crop safety, pre-emergent herbicides can be an important backbone of a successful weed management strategy.

This document highlights the factors to consider when planning a pre-emergent herbicide program.

Pre-emergent herbicides do require more planning when considering crop rotations, however the benefits of improved overall weed control and herbicide resistance management mean that pre-emergent herbicides have a fit in Central Queensland.

FACTORS INFLUENCING THE ACTIVITY OF PRE-EMERGENT HERBICIDES

1. What weeds are in the paddock and where are the weed seeds?
Knowing the species in the weed seedbank and where the seeds are located (i.e., mainly on the surface or distributed in the top 10cm) will be important for selection of the herbicide to be used and will assist in setting realistic expectations for control.

2. Weeds present:
A heavy weed burden at application can reduce the performance of all pre-emergent herbicides. Where applied to existing weed cover (i.e. in a mix with a knockdown herbicide) the pre-emergent herbicide deposited on the green leaf surface will enter the leaf and therefore not be available to the soil for residual control.

3. Is the herbicide subject to volatilisation or photodegradation?
Knowing this will determine the incorporation strategy required to minimise loss to the environment.

4. How soluble is the herbicide?
This will depend on how much rain is required for incorporation into the soil or to wash off stubble. Solubility has various implications including how easily the herbicide will impact the germinating weed or potentially damage a sensitive crop. The susceptibility of the chemical moving deeper into the soil profile with soil water or off-site in runoff can also result in crop injury or crop loss due to leaching.

5. What is the soil type and level of organic matter?
Sandy or low organic matter soils (low Cation Exchange Capacity; CEC) have fewer binding sites. Other factors being equal, more herbicide will be available for crop and weed uptake in lighter soil types than in a heavier or higher organic matter soil.

6. How tightly does the herbicide bind to soil and organic matter?
Herbicides that bind tightly, generally stay close to where they are applied (unless the soil moves) and will persist for longer. They will also be more difficult to wash off stubble.

7. What is the soil pH?
The pH affects how long some herbicides persist for and how available they are for plant uptake and soil binding.

8. Rainfall and temperature:
Rainfall after application is important for incorporation and to allow the herbicide to be available for root uptake. Rainfall and temperature also affect the rate of degradation. In addition, the primary breakdown pathway for most herbicides is microbial. Adequate soil moisture is critical for microbial activity.

At crop planting, heavy rainfall within days of herbicide application may cause washing of the herbicide into the planting trench. This concentration of herbicide around the crop seed is likely to cause significant crop damage.

9. Application rate:
Choice of application rate will affect the efficacy, length of effective residual life and possibly crop selectivity.

Product labels are developed to reflect how herbicides behave in the soil. Always read and follow product label directions.

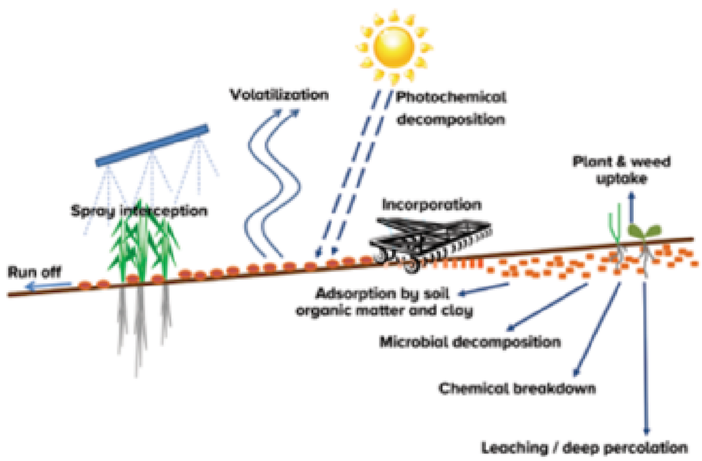

Figure 1. Interactions, loss and breakdown pathway of soil applied pre-emergent herbicides.

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HERBICIDE BEHAVIOUR IN THE SOIL

Once a pre-emergent herbicide is in the soil, an equilibrium is established between how much is bound to clay and organic matter (and is therefore not available for plant uptake); and how much is dissolved in the soil water and available for root uptake (Figure 2). 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; and the inherent binding strength of the molecule.

The type of soil often has a significant bearing on the performance of a pre-emergent herbicide. Soil texture (the ratio of sand, silt and clay) and soil organic matter will have an effect on the binding ability of the herbicide (adsorption). Cation exchange capacity is used as a measure of the soils' adsorption sites where binding can occur.

Heavier clay soils and soils with higher organic matter have more binding sites (higher CEC) and can bind more herbicide. Increased binding is likely to result in higher application rates being required to achieve a given level of weed control, as less herbicide is available in the soil water for uptake by germinating weeds. Increased binding also generally results in less leaching.

Conversely, in sandy or low organic matter (lower CEC) soils, there is less binding with more herbicide likely to be available in the soil water. This may lead to increased risk of injury to crops soon after application where there is a lot of freely available herbicide in the soil water, especially for highly soluble herbicides. As a result, some labels recommend a lower application rate in lighter soils.

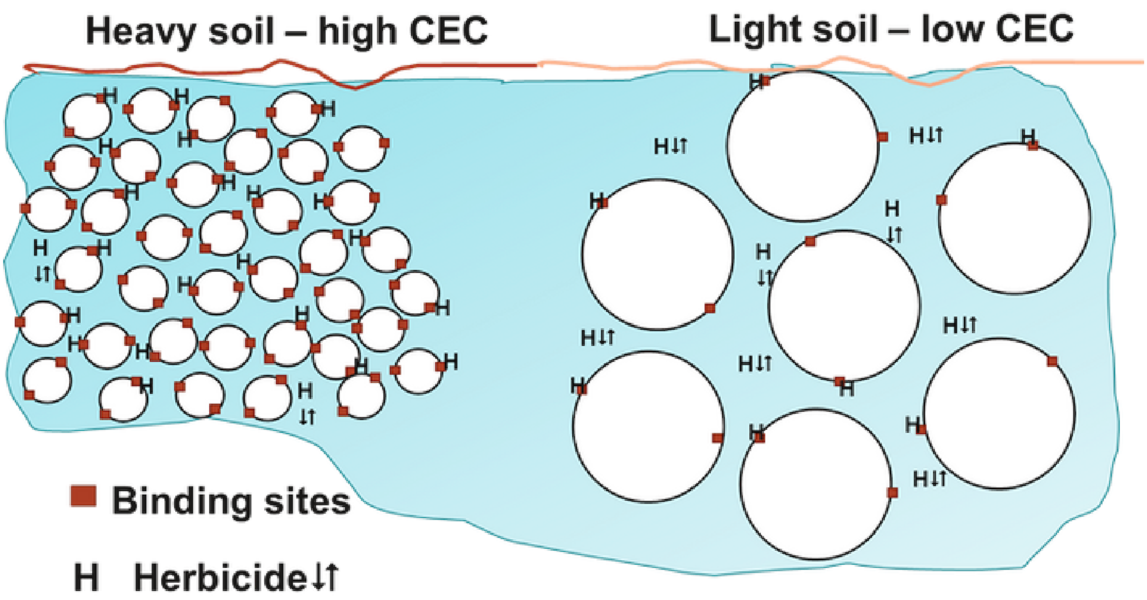

Figure 2. Indicative representation of a soils ability to bind to herbicides relative to soil type. Heavier soils have many more smaller clay particles with a greater overall surface area and binding sites compared to lighter soils with much larger sand particles. Consequently, there are fewer binding sites in lighter soils, which means that more herbicide will be available in the soil water. Additionally, soil pores are larger in lighter soils, meaning that soil water will move further, taking any dissolved herbicide with it.

PERSISTENCE

The length of time a herbicide remains in the soil can be highly variable and depends on the herbicide molecule, soil type, temperature, water, organic matter, speed and type of breakdown and application rate. Herbicide persistence is reported as the half-life or DT50 value. DT50 is the days of time that it takes for 50% of the herbicide in the soil to breakdown.

The rate of breakdown varies between different soils and environmental conditions. A comparison of herbicides with different DT50 values and the effects of heavy rainfall or prolonged dry periods is shown in Figure 3. Cropping plant back intervals are determined by a combination of the persistence of the herbicide, and the sensitivity of that crop to the herbicide. Be sure to always check the herbicide label for plant back intervals for each crop.

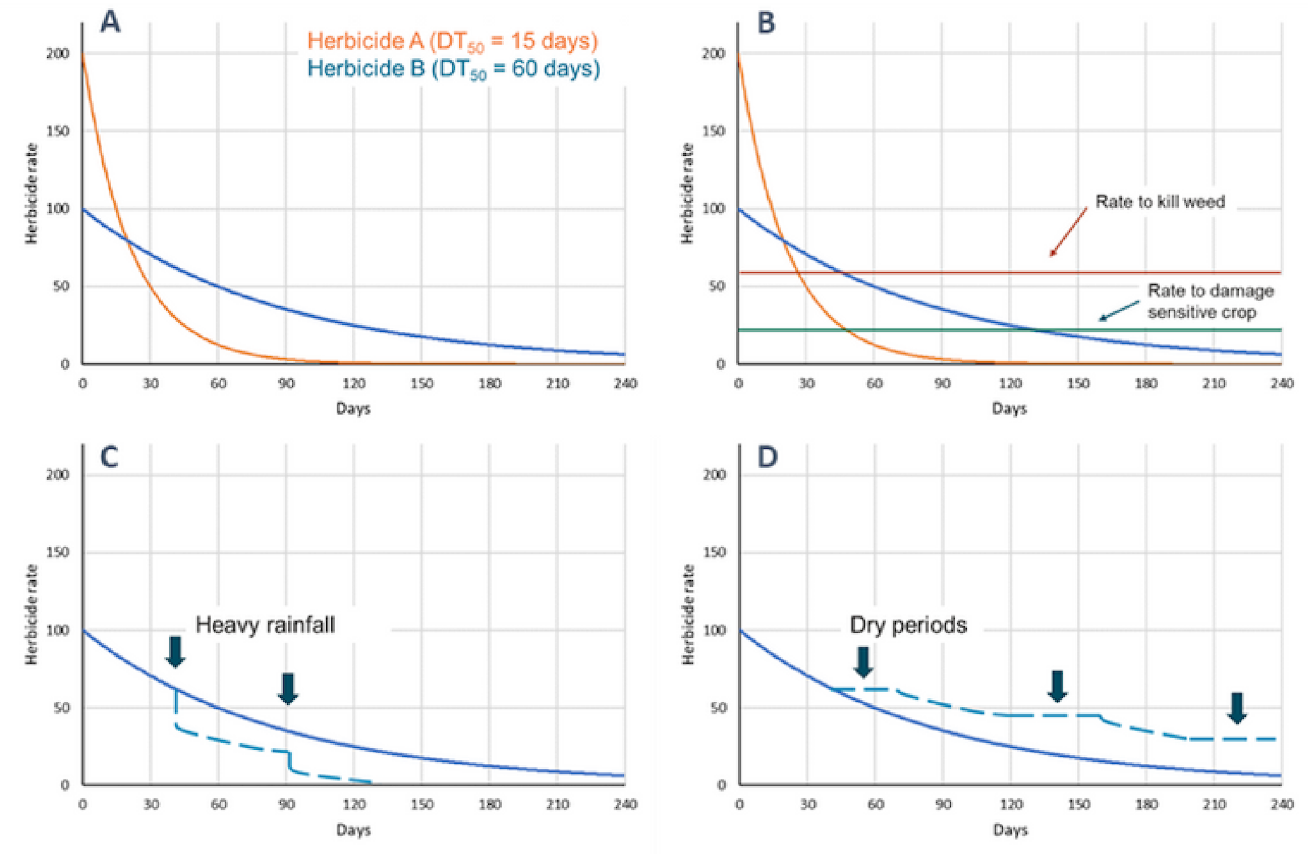

Figure 3. a) Comparison of persistence over time of two herbicides (herbicide A DT50 = 15 days; herbicide B DT50 = 60 days). b) Illustration of the duration of effectiveness on weeds and for damage to sensitive crops. c) Impact of heavy rainfall on decreasing persistence by leaching. d) Impact of dry periods on increasing the persistence of herbicides due to decreased microbial activity and reduced plant/weed uptake.

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SOLUBILITY AND BINDING

Solubility is a measure of how much herbicide can dissolve in water, an important consideration influencing incorporation by rainfall or irrigation and uptake by the germinating weeds. Solubility is usually quoted as mg/L of water at 20°C.

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 where they are more freely available to the plant or weed. However, if the herbicide is highly soluble it will tend to move with the soil moisture and be more likely to leach or cause off target effects.

When a herbicide is incorporated into the soil, a percentage will bind to the soil organic carbon and soil particles. Typically, this process takes 2-3 days. The degree of binding can be predicted by considering the Soil/Water Adsorption Coefficient (Kd).

The Kd value is the ratio of herbicide adsorbed onto the soil in comparison to the amount remaining in the soil water.

It is calculated as follows: Kd = (kg herbicide/kg soil) or (kg herbicide/L water)

As binding is highly influenced by the level of organic matter, the coefficient is often adjusted to take into account organic carbon levels in different soils and is presented as a Koc value. The Koc value is calculated by the equation:
Koc = Kd / soil organic carbon

The higher the Koc value, the more tightly the herbicide is bound. Herbicides with a low Koc are less tightly bound to the soil and more freely available in the soil water. As a result, they have greater capacity to move with the soil water, especially in sandy soil or soils with low organic matter.

Typically, the more commonly used pre-emergent herbicides in central Queensland tend to be herbicides with higher mobility (higher solubility and lower binding). These properties allow herbicides to be washed off stubble and incorporated into the soil with subsequent rainfall.

Herbicide	Solubility (mg/L at 20°C)	Average binding coefficient (K_{oc})	Comments
trifluralin (Treflan®)	0.22	15 800	Low solubility; likely to bind to soil and organic matter
pendimethalin (Stomp®)	0.33	17 491	
flumioxazin (Valor®)	0.8	889	Low solubility; slightly mobile
diuron (various)	36	680	
isoxaflutole (Balance®)	6	145	Low solubility; moderately mobile
terbuthylazine (Terbyne®)	7	230	
atrazine (Gesaprim®)	35	100	
prometryn (various)	33	400	
S-metolachlor (Dual Gold®)	480	200	Moderate solubility; moderately mobile
Picloram (Tordon®)	488	13	Moderate solubility; very mobile
saflufenacil (Sharpen®)	2100	9-55	High solubility; mobile – very mobile
imazapic (Flame®)	2230	137	High solubility; moderately mobile
metsulfuron (Ally®)	2790	12	High solubility; very mobile

Table 1. Examples of solubility and binding of selected pre-emergent herbicides.

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The addition of pre-emergent or residual herbicides enables more diversity to weed management programs.

The incorporation of residual herbicides into weed control programs provides weeks or months of ongoing weed control prior to commencement of the cropping phase and the use of in-crop herbicides.

Reducing weed emergence at planting or early post emergence ensures that in-crop herbicides are applied to a smaller weed population

HERBICIDE MOVEMENT OFF THE FARM

The proximity of Central Queensland highlands cropping to the Great Barrier Reef means that minimising herbicide movement off the farm into waterways is very important.

Herbicide movement off the treated area impacts on water quality and means decreased weed efficacy and increased risks for crop safety. Herbicides with high water solubility will easily move with water through the profile, and off the treated area into waterways with heavy rainfall. Herbicides that bind to the soil will move with soil particles in runoff during significant rainfall events. Delaying herbicide application when heavy rainfall events are imminent will minimise movement of water soluble herbicides.

Preventing soil movement is harder and involves either earthworks, providing adequate ground cover or vegetation buffer zones between the field and water ways to filter soil particles. Ground cover in the form of stubble or cover crops will affect the ability of the herbicide to get into the soil. Standing stubble will make it somewhat easier to get the herbicide to the soil. It is important to assess each situation individually to determine the best approach.

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MOA	Herbicide	Volatility and photodegradation	Solubility and Binding	Persistence	Factors to consider
Group 2	Imazapic (Impose®)	Low – will not rapidly breakdown on the soil surface	Highly soluble with moderate binding – readily washed off stubble, minor leaching from heavy rainfall. Binding increases with low pH.	Imazapic is very persistent due to slow microbial breakdown. Low soil pH and low soil moisture will increase its persistence.	Long persistence results in substantial plant backs, and rainfall requirements. Observe label constraints.
	Metsulfuron (Ally®)	Low – will not rapidly breakdown on the soil surface	Highly soluble with low binding – readily washed off stubble. Potential to leach with heavy rainfall.	Relatively fast breakdown providing soil is warm and moist. Persistence can be extended in dry soils; soils with alkaline pH	Legumes are particularly sensitive so observe plant back constraints especially in high pH soils
Group 3	Pendimethalin (Stomp® Xtra)	Can be subjected to losses from volatility and photodegradation. Mechanical incorporation preferred.	Low solubility and strong binding. Can be tied up stubble or plants. Once incorporated is bound tightly to where it is placed.	Moderately persistent. Will provide extended control. Primarily broken down by microbes therefore dry conditions will increase persistence.	Rotational crop constraints apply.
	Trifluralin	Will be subjected to losses from volatility and photodegradation. Mechanical incorporation soon after application required.	Low solubility and strong binding. Can be tied up on stubble or plants. Once incorporated is bound tightly to where it is placed.	Moderately persistent. Will provide extended control. Microbial degradation decreases under cool, dry conditions.	Avoid cereal varieties with short coleoptiles or seed treatments that shorten the coleoptile. Ensure seeds are sown below the herbicide band. Requirement for mechanical incorporation restricts use to cultivated systems.
Group 5	Atrazine (Gesaprim®)	Non-volatile. Some photodegradation can occur if left on soil surface without rainfall to incorporate.	Low solubility. Will require substantial rainfall to wash off stubble. Good soil moisture required for plant uptake. Binding is moderate, however reduced in sandy, low organic matter soils.	Moderately persistent, with increasing persistence under high soil pH and low soil moisture.	High rates result in considerable plant back for susceptible crops. Enhanced microbial degradation can occur where regular application occurs on the same soil.
	Terbuthylazine (Terbyne®)	Low volatility. Some photodegradation may occur when applied to warm soils without rainfall to incorporate.	Low solubility. Will require substantial rainfall to wash off stubble. Good soil moisture required for plant uptake. Binding is slightly higher than atrazine	Less persistent than other triazines. Persistence increases in dry conditions and with higher application rates	Heavy rainfall can move herbicide into the root zone and damage crops. Stronger soil binding may provide more consistent control of surface germinating weeds.
Group 5	Diuron	Low. Without rainfall to incorporate, some losses from volatilisation and photodegradation may occur over time	Low solubility. Relatively tight binding to organic matter will require substantial rainfall to wash off high stubble loads. Good soil moisture required for plant uptake. Soil binding is reduced in low clay and/or low organic matter soil.	Soil persistence is relatively high and has significant plant backs.	In soils where binding is low, heavy rainfall may move chemical down the profile resulting in crop injury.
Group 14	Flumioxazin (Valor®)	Non-volatile. Stable on the soil surface.	Low solubility and moderate-high binding will require substantial rainfall to wash off stubble or into the soil profile. Once incorporated should remain stable in the topsoil. Good soil moisture is required for consistent performance.	Persistence increases as application rate increases. Rotational crop constraints will apply.	Weeds germinating from depth with roots below the herbicide layer may result in poor control. Low persistence when applied at knockdown-only application rates.
	Saflufenacil (Sharpen®)	Non-volatile. Stable on the soil surface.	Highly soluble with moderate binding – readily washed off stubble, minor leaching from heavy rainfall.	Persistence increases with application rate. Refer to label for plant backs	Low persistence (except cotton and sunflowers) when applied at knockdown-only application rates.
Group 15	S-metolachlor (Dual Gold®)	Some volatility. Photodegradation can be significant if no rainfall to incorporate after application.	Moderate solubility. Rainfall that wets the soil to 2-5 cm will be adequate for incorporation. Binds more tightly to organic matter than clay.	Persistence is relatively short. In summer crop situations moderate persistence is achieved by higher application rates. Split applications may extend the period of residual control.	In soils with low organic matter and clay content, herbicide may move into the germination zone of the crop. Protect sorghum seed with seed safeners. Prone to leaching in heavy rainfall events.
Group 27	Isoxaflutole (Balance®)	Non-volatile. Stable on soil surface. Rainfall required to incorporate into soil.	Low solubility and moderate binding to organic matter. However, where a large rainfall event occurs following a dry period, herbicide residues may move down into the root zone, particularly on sandy or gravel soils.	Length of persistence is dictated by frequency and intensity of rainfall events post application. Rotational constraints exist for certain crops.	Following each rainfall event, some herbicide will convert to diketonitrile (DKN) which is the herbicidal compound.

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ADDITIONAL RESOURCES

Further information

Congreve, M. and Cameron, J. (eds) (2023). Soil behaviour of pre-emergent herbicides in Australian farming systems – a national reference manual for advisers. 3rd Edition. GRDC publication, Australia

Videos

GRDC: Pre-emergent Herbicides – Part 1 Solubility & Binding https://www.youtube.com/watch?v=s63GYYyflzw&t=1s

GRDC: Pre-emergent Herbicides – Part 2 Incorporation by Sowing https://www.youtube.com/watch?v=LJNjuMWS57U&t=1s

On-line learning

WeedSmart Diversity Era: Pre-emergent Herbicides 101 https://www.diversityera.com/courses/pre-emergent-herbicides-101

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PROJECT ACKNOWLEDGEMENTS

CRDC

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Queensland Government

NSW GOVERNMENT

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