Achieving crop selectively when using pre-emergent grass herbicides in winter cereal crops.

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Call to action/take home messages

- The use of pre-emergent herbicides at planting of winter cereals is on the rise, mainly as a result of resistance to post-emergent herbicides
- Some pre-emergent grass herbicides can damage winter cereals. Care must be taken to achieve acceptable crop selectivity
- Understanding the properties of the herbicide, where the herbicide is located relative to the crop seed, the soil type and the rainfall will guide how the herbicide should be applied and incorporated
- To achieve crop safety with some herbicides, attention to the planter type and set-up is essential to position the crop seed away from the herbicide.

Growers increasingly find it more difficult to achieve acceptable post-emergent control of grass weeds in winter crops due to herbicide resistance. This is resulting in increased use of pre-emergent herbicides applied at sowing.

Most pre-emergent grass herbicides can damage winter cereals, if they are taken up by the crop in sufficient concentration. Crop safety is a combination of herbicide properties, the rate applied, soil type, rainfall after application and crop type along with planter set up to create spatial separation of the herbicide and seed. Understanding these interactions assists in minimising the potential for crop injury.

Herbicide properties influence how they can be used

There are a wide range of pre-emergent herbicides available in Australia that control grass weeds

Table 1: Pre-emergent grass herbicides commonly used in key crops in Australia

Mode of action	Herbicide	Example	Wheat	Barley	Canola	Chickpea	Faba bean
D	Trifluralin	TriflurX®	✔	✔	✔	✔	✔
D	Pendimethalin	Stomp®	✔	✔	✔	✔	✔
D	Propyzamide	Rustler®			✔	✔	✔
G	Flumioxazin	Terrain®	✔			✔	✔
J	Tri-allate	Avadex®	✔	✔	✔	✔	✔
J	Prosulfocarb	Arcade®	✔	✔			
J+K	Prosulfocarb + s-metolachlor	Boxer® Gold	✔	✔		✔	✔
K	S-metolachlor	Dual® Gold	✔	✔	✔		
K	Metazachlor	Butisan®			✔		
K	Pyroxasulfone	Sakura®	✔			✔	
Several additional pre-emergent herbicides are scheduled for commercial release in 2020/2021							

These herbicides are active on a wide range of grass weeds. Herbicide selection is often based more on crop tolerance, resistance status, rotational crop and compatibility with the farming system (disc v tyne planters; tilled v non-tilled; amount of stubble retained).

One key to reducing the likelihood of crop damage when using pre emergent is to keep the herbicide away from the germinating seedling. This can be achieved in modern farming techniques through the timing of the herbicide application and the use of the sowing process to move the herbicide away from the seed. This is discussed further below.

However, under certain circumstances, herbicides can move from their intended position in the soil. This movement may occur via movement in soil solution (water) or physical movement, whereby soil with herbicide bound to it can move back closer to the seed.

Mobility in the soil solution is largely dictated by the properties of the herbicide i.e. an interaction between the solubility of the herbicide and its ability to bind to organic matter and soil, along with the soil type and amount, timing and intensity of rainfall. Herbicides with lower mobility in soil solution are generally safer to use, provided physical separation can be achieved in the first instance. More mobile herbicides can move despite the best attempts at physical separation and as such may be too dangerous to use in cereal crops and limited to use in broadleaf crops only.

Table 2: Soil mobility of key pre-emergent cereal herbicides
N.B. Check labels for use patterns in individual cereal crops

Tight binding. Very low mobility.	**Relatively tight binding.**	**Low mobility.**	**Some mobility.**	**Mobile.**
pendimethalin trifluralin	prosulfocarb tri-allate	flumioxazin	pyroxasulfone	s-metolachlor
Well suited to IBS (incorporate by sowing) with tynes				Higher potential for crop damage

Sandy soils, or soils with very low organic matter and other soils with low cation exchange capacity (i.e. CEC <5) have fewer binding sites, and therefore less ability to bind all herbicides than heavier soils. This results in more herbicide available in the soil water, and therefore more available to be taken up by the crop. All other things being equal, more damage will result in these lighter soils where more of the applied herbicide is likely to be available to the crop and the weeds.

Binding to soil and organic matter takes some time to occur, even with herbicides of lower mobility. Where herbicide has been applied to the soil surface and a large rainfall event occurs before the herbicide has been incorporated and had time to bind, substantial damage may still occur. This will be particularly problematic where the soil profile is dry and the wetting front rapidly moves through the profile, taking the herbicide with it before it has a chance to bind.

Conversely, a mobile herbicide applied to the soil surface may often result in no crop injury should there be no, or only small rainfall events, between planting and emergence and the herbicide is not washed into the seed zone.

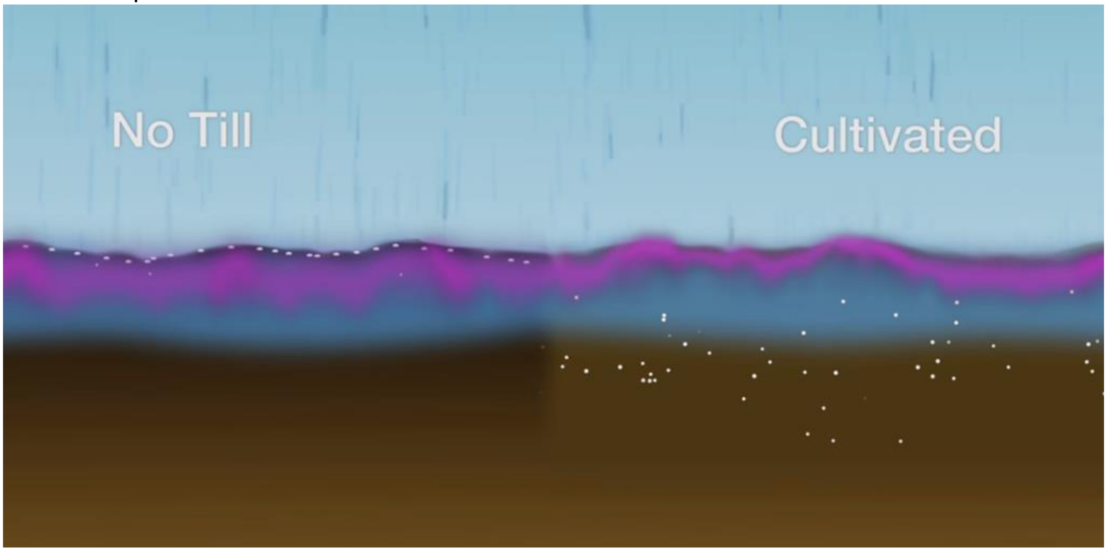
Physical movement of herbicide however is much less predictable and manageable. In the northern grain region, the unpredictability in rainfall intensity during the critical period from planting to emergence, ranging from no rainfall through to a heavy storm event, can make the use of preemergents more challenging. A large rainfall event that also results in temporary waterlogging, and reduces the crops ability to metabolise the herbicide, can be particularly damaging.

These conditions can also impact on early crop nutrition which can further exacerbate crop damage. For example, where a sulfonyl urea herbicide has been applied and temporary waterlogging occurs, this can limit to ability of the crop to take up adequate zinc from the soil and therefore display zinc deficiency.

Where are the weed seeds?
To achieve good outcomes from the use of pre-emergent herbicides it is also important to understand where the weed seeds are located in the soil, as this will influence the ability to control them when they germinate.

In recently tilled paddocks it is likely that weed seeds will be mixed to the depth of cultivation. Self-mulching soils can also have a similar effect, incorporating a proportion of the seed bank below the soil surface. Seeds of wild oats can also work their way deeper in the soil profile, even in the absence of cultivation.

Weeds emerging from depth are likely to be poorly controlled by non-mobile pre-emergent herbicides positioned near the soil surface.



To reach weeds seeds germinating at depth either:

- A mobile herbicide will be required, or
- If a non-mobile herbicide is used, it will require mechanical incorporation immediately after application to the depth of weed seeds.

Either of these strategies increase the risk for crop injury if the herbicide is not kept away from the germinating crop.

After a few years of zero / minimum tillage, most grass weed seeds at depth have died or germinated, with the remaining grass weed seeds located near the soil surface. In these situations, less mobile herbicides can be effective when applied near the surface with shallow incorporation. Concentrating herbicide and weed seed in a narrow band near the surface may also result in improved weed control.

How can we use pre-emergent herbicides to get the best control with limited crop damage?

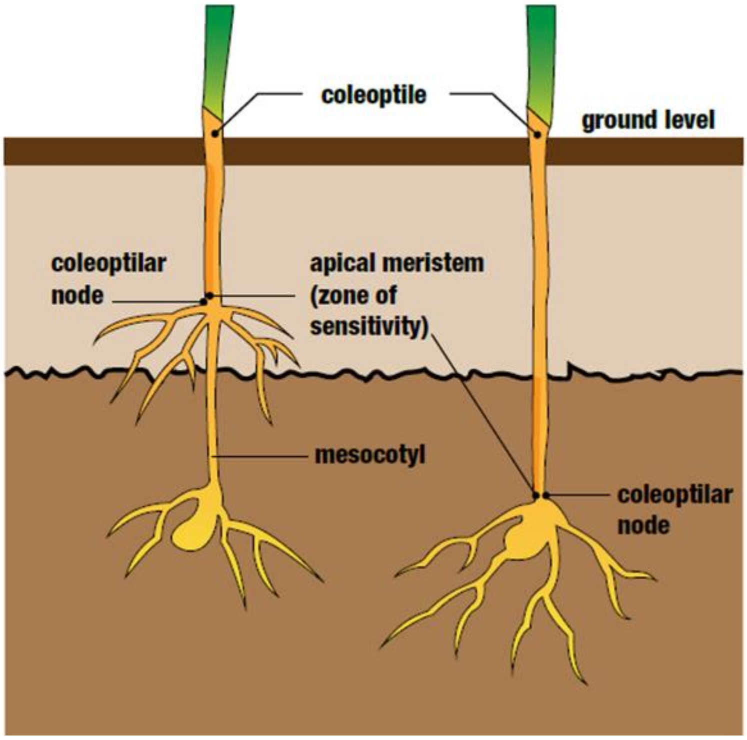
Positional selectivity
Cereals have a degree of sensitivity to all the registered pre-emergent herbicide options available. It is therefore desirable to place the seed away from these herbicides to minimise any impact. Placing the seed away from the herbicide introduces what is termed "positional selectivity".

In placing the seed away from the herbicide both the horizontal and vertical separation is important.

Vertical separation – think of this as placing the seed under the herbicide band. Depending upon the individual pre-emergent herbicide, it will enter the seedling either though the roots taking up herbicide dissolved in the soil water, or by transfer of herbicide through the emerging shoot, in particular through the coleoptile node.

Positioning a low mobile herbicide near the soil surface should keep it above the roots of the crops (unless there is excessive rainfall on soils with low ability to bind the herbicide). This can allow for acceptable safety for non-mobile herbicide reliant on root uptake.

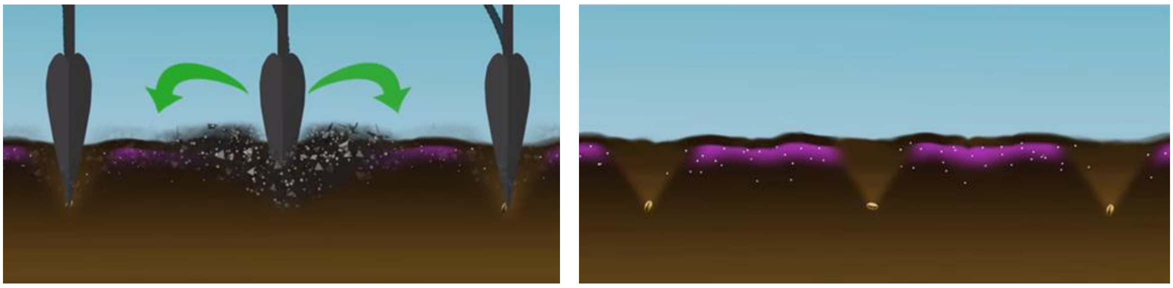
For herbicides that enter via the coleoptile node (e.g. trifluralin, pendimethalin, tri-allate, s-metolachlor in particular) it is important to keep the coleoptile node away from the herbicide. This is easier to achieve in wheat and barley as the coleoptile node stays close to the seed (RHS of picture). In most grass weeds (and crops such as oats, sorghum, maize) the mesocotyl elongates during emergence (LHS of picture) and pushes the coleoptile node towards the surface. Weed control with these herbicides primarily results from herbicide absorption through the coleoptile node as it moves into the herbicide zone near the seed surface.



Additional horizontal separation can be achieved by using the planting operation to throw herbicide treated soil out of the furrow and into the inter-row, commonly referred to as 'incorporation by sowing using knife points and press wheels', or IBS for short.

The principle of IBS works well for herbicides with low mobility (e.g. trifluralin, tri-allate, prosulfocarb). Soil-throw from the planting furrow removes a significant quantity of herbicide treated soil into the inter-row, and the low solubility means that the herbicide is less likely to move horizontally in the soil water following rainfall.

Additionally, weed seeds present on the soil surface in a zero till situation are also thrown into the inter-row, where the majority of herbicide is present. For herbicides that are volatile (e.g. trifluralin, triallate in particular), incorporation by the sowing operation is also required soon after application to avoid significant volatility losses.



However, where there have been high seed banks over several years it is likely that seed is abundantly mixed in the surface soils from previous years seeding. In this case, herbicide displaced from the seeding row may allow remaining seeds within the row to establish in the drill line.

The vertical and horizontal separation in minimum tillage tyne systems is generally simple to achieve, as illustrated in the figure above. There are however four scenarios to be mindful of:

1. When sowing in wet, heavy soils the slot may not be adequately closed or back filled by untreated soil. Where the planting slot is left open, even small rainfall events may concentrate herbicide directly in and around the seed.
2. Soil displaced from one row may be thrown into the adjacent row. This places herbicide treated soil over the seed in the adjacent row, while also has the effect of increasing seed depth that may exceed coleoptile length of the planted crop. Selection of point or opener design to match soil throw to row spacing will be required, along with calibration of ground speed to match prevailing soil conditions
3. Heavy rainfall after planting, physically moving treated soil back into the planting furrow
4. Soil prone to furrow walls collapsing.

As such growers need to be mindful of their planter set up when considering using pre-emergent herbicides. Narrow row spacing make it more difficult to contain soil throw to the inter-row, however this will be highly influenced by planting speed. Conversely, very wide row spacings (>30cm) may result in more volatile herbicides not being adequately covered by soil and potential for reduced herbicide performance due to volatility losses. Heavy soils can be “cheesy” when wet and less consistent in their flow, compared to lighter or red soils.

The point design used can also influence the amount of soil throw as well. Inverted T boot points can increase soil throw, but also increase tilth created. Therefore, they can get better back fill over the seed but increased risk of overthrow to the adjacent furrow. Strait knife points may not achieve as much herbicide displacement and may also leave the slot open, due to the lack of tilth created.

Double or split boot systems designed to create separation between fertiliser and seed often requires increased planting depth, as is the also the case when moisture seeking (planting deeper into sub-soil moisture). Increased seeding depth will result in increased movement of soil to the interrow and increased potential to throw treated soil into adjacent rows.

With so many variables involved in soil throw it is hard to make specific recommendations. A useful approach is to use urea as a visual surrogate for herbicides in paddocks where pre-emergent herbicides are being considered. To do this simply hand spread a relatively heavy rate of urea on a small area (1M x 1M) of the paddock. Use a liberal rate to ensure it is easy to see the granules. Run the planter through this area at your decided depth and speed. Following the machine pass, check to see where the urea has been moved to assess soil trow, and the seed placement in relation to the urea granules. Where problems are observed adjust the planter or travel speed and repeat the operation on a new part of the soil.

A GRDC video demonstrating how this can be done can be accessed at https://www.youtube.com/watch?v=LJNjuMWS57U&t=13s

Another method to assess soil throw "on the go" in variable conditions is to observe the soil throw on the outside tine of the seeder. If a significant amount of soil is thrown further than the distance to the next row this can suggest there may be potential for damage.

Soil throw from disc seeders vary greatly, although commonly results in minimal soil-throw. This often means herbicide is not sufficiently moved away from the emerging cereal which results in greater crop injury. The potential for crop damage is further increased when there is shallow seeding depth and an incompletely closed seed furrow. The lack of soil-throw also does not protect volatile herbicides from volatility losses. Some disc seeder designs and/or modification can result in more soil throw and better displacement of the herbicide from on top of the seed row however they can be variable in their performance.

For more information
GRDC: Pre-emergent herbicides - Pt 1 Solubility & binding
https://www.youtube.com/watch?v=s63GYYyflzw&t=13s

GRDC: Pre-emergent herbicides - Pt 2 Incorporation by sowing
https://www.youtube.com/watch?v=LJNjuMWS57U&t=13s

Herbicides in Australian farming systems: A reference manual for agronomic advisers
https://grdc.com.au/SoilBehaviourPreEmergentHerbicides

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