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Balancing crop safety and effectiveness when using Pre-Emergent Herbicides

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Damage to emerging crops is common. Understanding a few basic principles about herbicide behavior and crop tolerance can reduce the chance of crop damage significantly. Here are a few things to think about to get the best out of your pre-emergent weed control.

Some tips for using pre-emergent herbicides

- Herbicide efficacy is reduced when there is more than 50% stubble cover. It is best to leave stubble standing rather than laying over. Straw choppers on headers are fantastic as they mulch and pulverize stubble into chaff, which breaks down faster. This is much better than slashers that leave stubble in long lengths and act as a thatch that limits chemical access to the soil surface.
- Knifepoints and press wheels allow greatest crop safety as they throw chemical out of the furrow. Be aware that this can result in weeds in the furrow.
- If using a disc seeder, understand the mechanics of your machine and the limitations it may carry compared to a knife point and press wheel. What are the depth wheels and closer mechanisms doing to soil in the seed row?
- Pay attention to detail in your sowing operation and ensure soil throw on the inter-row whilst maintaining a seed furrow free from herbicide. Concentrated chemical soil in the furrow can cause crop damage and reduce plant vigour.
- Ensure the seed furrow is closed to prevent herbicide washing onto the seed. Seeding systems vary in their ability to “close the slot.”
- Ensure even seed placement, typically 3–5 cm of loose soil on top of the seed in cereals for best crop safety. This is a key safety mechanism. Whatever else you do, keep the seed below 3cm if in marginal conditions or in crops sensitive to particular herbicides. If you can’t – wait for better conditions!
- Incorporate by sowing (IBS) rather than Post Sowing Pre-Emergent (PSPE) for crop safety.
- Understand herbicide chemistry. Choose the right herbicide in the right paddock at the right rate. Crop tolerance varies considerably.

How do pre-emergent herbicides work?

Pre-emergent herbicides work in a number of ways. Generally, they are applied to the soil and either taken up by the emerging root, shoot, or a combination of both. Some also have leaf activity, but that is not usually as important as ideally these herbicides are applied to weed free seedbeds.

The specific site of ‘root’ or ‘shoot’ uptake varies between each herbicide and mode of action, giving each

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herbicide group its unique weed control attributes.

All pre-emergent herbicides however need at least some soil moisture or ideally rainfall following application to become 'activated' and available to weed seeds. Until this occurs, uptake may be limited and weed control may be poor.

Some are sensitive to sunlight and need to be mixed into the soil or covered by soil to minimise losses. Herbicides like trifluralin need only a light cover of soil to reduce photodegradation. Some are volatile and can be lost to evaporation, especially from wet soil.

Table 1. How common pre-emergent herbicides work once applied to soil

Mode of action	Herbicide example	Uptake	Volatility* and/or degradation by sunlight	Water solubility
B – Sulfonyl ureas	Logran® (triasulfuron)	Roots and leaf – quickly translocated to the growing points preventing any further growth.	Low	High (increases with alkalinity)
	Glean® (chlorsulfuron)	Roots and leaf – quickly translocated to the growing points preventing any further growth.	Low	Med/High
C – Triazines	atrazine	Roots and leaf – quickly translocated inhibiting photosynthesis.	Low	High
	simazine	Roots – quickly translocated inhibiting photosynthesis.	Low	Low
	Terbyne® (terbuthylazine)	Roots – quickly translocated inhibiting photosynthesis.	Low	Med
C – Ureas	diuron	Roots and leaf – quickly translocated inhibiting photosynthesis.	Low	High
D – Dinitroanilines	Triflur® X (trifluralin) and Stomp® (pendimethalin)	Roots – inhibiting microtubule assembly.	High	Very Low
H – Isoxazoles	Balance® (isoxaflutole)	Root and shoots – inhibits the enzyme HPPD which in turn causes death of chloroplasts and consequently plant death.	Low	Med (but this is complex with Balance®)
J – Thiocarbamates	Avadex® Xtra (triallate)	Shoots (predominantly) – inhibits fat synthesis.	Very High	Low
K – Chloroacetamides	Boxer Gold® (prosulfocarb + S-metolachlor)	Shoot, root and leaf – inhibits cell division. This product also contains Group J as well.	Low	Med
K – Isoxazolines	Sakura® (pyroxasulfone)	Root and shoot – inhibits very long chain fatty acid biosynthesis, causing the growing point and coleoptile to be interrupted.	Low	Med

(Haskins, B. 2012)
Volatility varies significantly depending on soil moisture and temperature at the time of application and immediately after. As both temp and moisture levels increase, so does the rate of volatilisation.

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Principles of incorporation

In no till systems the seeder usually includes a knife point (<12 mm wide) or disc followed by a press wheel. Row spacings are generally 25–33 cm wide. Many seeders are now towed by a tractor on GPS guidance, which allows the seeding row to run in between last years stubble row.

Pre-emergent herbicides require either physical incorporation or rainfall incorporation to be effective. The amount of physical or rainfall incorporation required varies according to the herbicide chemistry, rate and prevailing conditions.

Physical Incorporation

The most widely used method of incorporating pre-emergent herbicides is by physical incorporation. This involves incorporating the herbicide within the soil to minimise volatilisation and degradation from sunlight. This is particularly important with trifluralin, the most commonly used herbicide in Australia.

Rainfall incorporation

Many pre-emergent herbicides can be applied to the soil pre or post sowing without physical incorporation and are relatively stable in sunlight. They do require a certain amount of moisture in the soil and rainfall after application to be effective. The more soluble pre-emergent herbicides typically have low volatility.

Incorporated By Sowing (IBS)

Application of pre-emergent herbicides pre-sowing and then incorporating them into the seedbed during the sowing process will often increase safety to crops because the sowing operation removes a certain amount of herbicide away from the seed row. This can, however, reduce weed control for the very same reason, as chemical is moved out of the seed row. In this case it is wise to include a water-soluble herbicide into the mix with the aim to have some herbicide wash into the seed furrow.

Post Sowing Pre-Emergence (PSPE)

Some pre-emergent herbicides can be safely applied after sowing (before crop and weed emergence). Most will require rainfall to give good, reliable weed control. The margin for crop safety can be low, particularly if there is high rainfall soon after application or the seeding row is left as a furrow.
The preferred method of applying pre-emergent herbicides in conservation farming systems is by IBS, as crop safety is maximised, stubble remains standing to protect the seedbed, and soil disturbance is minimised.

Incorporation by Sowing (IBS) aims to:

- Minimise soil disturbance to limit soil moisture losses and limit seed burial to depth. Most of these pre-emergent herbicides work predominantly by root uptake, so by leaving the seeds on the surface and applying the herbicide directly to that surface we are giving the herbicide the best chance to work effectively.
- Throw soil in between rows but not onto neighbouring rows. This 'hot bed' of herbicide treated soil on

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the inter-row (in between seed rows) forms a concentrated layer of herbicide, which increases weed control.

- Leave the seed furrow free of herbicide treated soil. This allows the crop to emerge from a microenvironment free of herbicide, maximising crop establishment and vigour. The negative is that in high weed pressure situations weeds can emerge in the row. Crop competition usually limits the effect that these weeds establishing in the plant row have on yield.
- Maintain a constant crop seed depth so that in the event of any herbicide washing into the seed furrow, the fragile crop root system is below the herbicide layer. This is termed 'closing the slot', and is particularly important when sowing in wet conditions on clay soils. If the 'slot' is not closed, herbicide may wash directly onto seeds causing significant crop damage.

Will efficacy be reduced if I apply herbicides to dry soils?

Most herbicides will remain active if applied to a dry soil surface. Providing sufficient rainfall occurs after application to wet up the top few centimetres where the herbicide is concentrated and weeds germinate, application to dry soils is fine.

What is the importance of herbicide solubility?

Understanding solubility of herbicides allows us to understand where they might end up in the soil. It also helps us understand whether they will wash off stubble. A soluble herbicide will wash off stubble, a non-soluble herbicide will not. Most are reasonably soluble and will move with the water through the soil profile. Trifluralin, Stomp and Avadex are the exceptions to this as well as simazine and, to some extent, diuron.

Herbicides with low solubility need more rainfall to move them off stubble and into the soil and will then move more slowly through the soil profile. That is why trifluralin needed incorporating in cultivation systems.

Does herbicide move faster in dry soils?

Yes! Where chemicals end up in the profile depends on a number of factors. Firstly, if a soil is dry, any rainfall will move more rapidly through the profile than if the soil is wet. Depending on the amount and intensity of rain, and the soil type on which it falls, crop damage may well occur if the herbicide is moved rapidly through the profile.

Be very cautious about using a herbicide on a crop with a low crop safety margin on a dry soil if a significant rainfall event was forecast (greater then 25mm.) Risk is much higher on sandy soils as there is no clay and little organic matter to bind water and adsorb chemical. Stubble cover will impact on crop safety and act partially as a buffer to slow infiltration rates.
Increase the safety margin by planting deeper. (4-5cm depending on crop type – pulses will handle greater planting depths.) Using high rates of metribuzin on sand for brome grass control can often cause crop damage.

Influence of soil type on herbicide performance?

Herbicides have electrical charges that cause them to bind to the positive or negative charges in the soil and organic matter particles. This process is called adsorption. Herbicide adsorption varies with soil pH, soil organic matter content, and climate. When spraying a soil-applied herbicide, remember:

- Soils high in organic matter or clay are the most adsorptive. These soils may require higher rates or more frequent herbicide applications than sandy and coarse soils.

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- Herbicide carryover and crop injury are more likely to occur in sandy and coarse soils, as less herbicide is adsorbed to the soil
- The risk of herbicide carryover varies with soil pH. Examples of this are Logran and Glean which are highly persistent in high pH soils and Spinnaker which is persistent in low pH soils.

What is herbicide volatilization?

This refers to the transformation of solid or liquid herbicide into gas. Volatilization increases with air temperature, soil temperature and wind speed. Volatilization decreases with high relative humidity. Volatilization can be reduced through the incorporation of the herbicide into the soil by mechanical incorporation or rainfall. Most disc systems will throw enough soil around in dry conditions to limit the volatilization losses of products like trifluralin.

What about leaching?

Herbicide movement through the soil profile with water is known as leaching. Among the factors that influence leaching are the herbicide water solubility, the soil structure and texture, and the amount of water passing through the soil profile. For example, while glyphosate and trifluralin have low leaching potential due to their strong adsorption to soil, moderately to weakly adsorbed herbicides such as atrazine can be lost from the soil profile with water.

Herbicide molecules that are strongly adsorbed to soil particles are less likely to leach. Herbicide leaching increases in coarse and sandy soils with low organic matter.

How does stubble and ash affect pre-emergent herbicide effectiveness?

Stubble affects pre-emergent herbicides in two ways. It is a physical barrier that impedes herbicide from reaching the soil, and it can also tie up some herbicides making them unavailable for weed control.

In general, many pre-emergent herbicides may still be used effectively with up to 50% stubble cover in a paddock. This is a large stubble load, and can be estimated by looking down onto a stubble from above and assessing the area of soil/stubble ratio. Once stubble loads increase above 50%, pre-emergent herbicides will still work, however maybe not to their full potential.

Whilst using pre-emergent herbicides in stubble has limitations, there are some things that you can do to ensure an effective job:

- Managing stubble starts at harvest. Ensure that trash is spread evenly across the header width, as trash concentrations in the header row can bind to herbicides producing very poor weed control. Remember the header row is also where many weed seeds are concentrated. Consider stripper fronts or windrow burning if header trails become too thick.
- Leave stubble standing upright. Laying stubble onto the ground either across a whole paddock by harrowing or in smaller areas as a result of traffic lines reduces the amount of herbicide that reaches the soil, as the stubble takes up greater surface area when laid over compared to when standing.
- Using higher water rates (>80 L/ha) with larger non air-inducted droplets (coarse) will aid in getting more herbicide to the soil. Matching row spacing and nozzle spacing on RTK guidance also allows precise

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positioning of nozzles in between stubble rows, minimising stubble shadowing of herbicide.

- Select herbicides that are more suited to situations where there are high stubble loads. Some herbicides are tied up by stubble and some can wash off stubble onto the soil, maintaining their efficacy for weed control. See Table 2.
- Use higher rates of herbicide. This example is particularly important for products like Triflur® X, which has label recommendations that support higher rates of product for use in higher stubble load situations.

Table 2. Effectiveness of common pre-emergent herbicides in high stubble load situations.

Herbicide	Suitability for use in high stubble loads	Comments
Logran® (triasulfuron), Glean® (chlorsulfuron) and diuron.	Yes	Will wash off stubble
atrazine and simazine	Yes	Will wash off stubble
Terbyne® (terbuthylazine)	Yes	Will wash off stubble
Triflur® X (trifluralin), Stomp® (pendimethalin) and Avadex® Xtra (triallate)	Maybe	Stubble will tie up products. Use higher label rates.
Balance® (isoxaflutole)	Yes	Will wash off stubble
Boxer® Gold (prosulfocarb)	Yes	Will wash off stubble
Sakura® (pyroxasulfone)	Yes	Will wash off stubble

Modern labels will suggest adequate control with up to 50% stubble cover.

Crop safety margins

Table 3 aims to highlight the experiences gained across a number of trials since 2004. It is important to note that if a herbicide is safe on crop emergence in one situation, it may not be in the next situation, and this table tries to capture those experiences.

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Table 3: Crop safety margin and need for incorporation on a range of crop types with commonly used herbicides

Crop	Herbicide	Need for mechanical incorporation	Crop safety margin in adverse conditions
wheat, barley	trifluralin	high	Very low. High rates worse.
wheat, barley	Stomp® (pendimethalin)	medium/high	Medium. High rates worse.
wheat, barley	Boxer® Gold (prosulfocarb)	low/medium*	Medium. High rates worse.
wheat	Sakura® (pyroxasulfone)	low/medium*	Medium/High
wheat, barley	Avadex® Xtra (triallate)	medium/high	Low. High rates worse.
wheat	Logran® B (triasulfuron)	low*	High. Little damage most trials.
wheat**, barley**, chickpeas, fieldpeas	diuron	low*	High. Little damage most trials.
wheat**, barley**, chickpeas, fieldpeas	metribuzin	low*	Low cereals. High rates worse. Medium: pulses.
chickpeas	simazine	low*	Medium.
chickpeas, fieldpeas	Terbyne® (terbuthylazine)	low*	Low/Medium.
chickpeas	Balance® (isoxaflutole)	low*	Low. High rates worse.
fieldpeas	Spinnaker® (imazethapyr)	low*	Medium. High rates worse.

* Rainfall is required to activate and/or incorporate the herbicide. Labels may recommend physical incorporation.

** These crops may not have registration for this product in some states.

Be aware of registration limitations of some products with regard to disc seeders.