NSW GOVERNMENT Department of Primary Industries

Using pre-emergent herbicides in conservation farming systems

WEED MANAGEMENT

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Top tips for using pre-emergent herbicides

- Only use pre-emergent herbicides as part of an integrated weed control plan including both chemical and non chemical weed control practices.
- Preparation starts at harvest. Minimise compaction and maximise trash spreading from the header.
- Minimise soil disturbance allowing weed seeds to remain on the soil surface.
- Leave stubble standing rather than laying it over.
- Knife points and press wheels allow greatest crop safety. Avoid harrows.
- 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.
- Pay attention to detail in your sowing operation and ensure soil throw on the inter row whilst maintaining a seed furrow free from herbicide.
- Ensure the seed furrow is closed to prevent herbicide washing onto the seed.
- Ensure even seed placement, typically 3–5 cm of loose soil on top of seed in cereals for best crop safety.
- IBS rather than PSPE for crop safety.
- Understand herbicide chemistry. Choose the right herbicide in the right paddock at the right rate.

Key words

***Pre-emergent herbicide*:** A herbicide applied to the soil either before or directly after sowing and prior to weed emergence.

***Incorporated By Sowing (IBS)*:** When a herbicide is applied just before sowing (usually in conjunction with a knockdown herbicide such as glyphosate) and soil throw from the sowing operation incorporates the herbicide into the seedbed.

***Post Sowing Pre-emergent (PSPE)*:** When a pre-emergent herbicide is applied after sowing (but before crop emergence) to the seedbed.

***Residual herbicide*:** A herbicide that has continued activity in the soil for a period of time reducing weed seeds germinating and/or growing in the soil.

***No till*:** The most common seeding method used in a conservation farming system, where a knife point and press wheel are used as the sowing method, disturbing less than 20% of the seedbed.

***Zero till*:** Where a disc seeder is used as the sowing method, disturbing less than 5% of the seedbed.

Introduction

Conservation farming adoption has grown to the point where over 80% of the cropping area in some regions of NSW are grown under a conservation farming system. In this system, cultivation is eliminated and seeding systems are designed to pass through retained stubble with minimal soil disturbance.

This has brought with it many advantages such as higher yields and water use efficiency, lower labour requirements, better soil structure and lower levels of soil erosion.

The downside however has been the higher reliance on herbicides for weed control. This has increased the level of reported herbicide resistance in NSW, and consequently the necessity to use integrated approaches to manage the impact of weeds.

Why use pre-emergent herbicides?

Pre-emergent herbicides are an essential part of a conservation farming system for a number of reasons:

(a) They can offer alternative modes of action to post-emergent knockdown herbicides,

(b) Many are very effective on hard-to-kill weeds such as annual ryegrass and barley grass,

(c) The current level of herbicide resistance to pre-emergent herbicides in NSW is very low,

(d) Pre-emergent herbicides control weeds early in crop life and potentially over multiple germinations, maximising crop yield potential,

(e) They suit a no till seeding system with knife points and press wheels and/or disc seeders,

(f) They can be cost effective.

Whilst pre-emergent herbicides can be used in conservation farming systems, they must be used in conjunction with herbicide/crop rotation management plans and other non chemical weed control techniques. These methods usually aim to minimise weed seed production and may include fallows, crop rotations including pastures and/or cutting hay, burning full paddocks or windrows, chaff carts, and weed seed destructors.

Non herbicide weed control options such as cultivation may not fit into a conservation farming system, but in many cases are a useful tool to reduce the reliance of herbicides for weed control and consequently herbicide resistance.

The more tools that are used to minimise weed seed set the lower likelihood of developing and progressing herbicide resistance.

Table 1. Percentage of paddocks with herbicide resistant annual ryegrass in cropping regions of Southern Australia (Source: Herbicide resistance surveys, GRDC Projects UA00098 and UA00104)

Region	Year	Populations resistant (%)										
		Boxer Gold®	Glean®	Sakura®	simazine	trifluralin	Achieve®	Axial®	glyphosate	Hoegrass®	imazapic /imazapyr	Select®
SA – Mid North	1998	nt	22	nt	nt	9	nt	nt	nt	38	nt	19
SA – Mid North	2003	nt	75	nt	nt	49	51	40	nt	76	nt	36
SA – Mid North	2008	nt	73	nt	nt	40	64	59	nt	76	nt	40
SA – Mallee	2007	nt	67	nt	nt	19	2	2	nt	6	nt	2
SA – South East	2007	nt	69	nt	nt	39	50	53	nt	60	nt	41
Vic – Western	2005	nt	57	nt	nt	5	28	30	nt	35	nt	12
Vic – Northern	2006	nt	43	nt	nt	2	nt	34	nt	40	nt	11
NSW – SE	2008	nt	70	nt	nt	6	nt	nt	nt	81	nt	21
NSW – Southern	2010	nt	53	nt	0	0	32	nt	0	56	38	4
Tasmania	2009–10	nt	24	nt	0	1	nt	nt	0	18	7	1

nt = Not tested. No resistance in the field has been recorded for Boxer Gold® and Sakura®.
Source: NSW DPI, *Weed control in winter crops 2012*, Herbicide resistance management, page 60.

Table 2. Return on investment from pre-emergent herbicides in 5 trials in NSW

		Nil herbicide yield (t/ha)	Yield (t/ha)*	Profit increase ($/ha)**	Return on investment (%)
Hillston	2010	3.47	5.25	$288	900
Rankins Springs	2010	3.06	3.77	$105	457
Ungarie	2010	2.31	4.5	$364	1213
Hillston	2011	2.6	3.46	$180	1800
Wirrinya	2011	1.72	2.5	$172	1048
Average				$220	1084

* = Yield from highest yielding treatment.
** = Profit increase calculated by the cost of herbicide and market value of grain for individual sites.

How do pre-emergent herbicides work?

Pre-emergent herbicides work in a number of ways. In short, 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 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 to minimise losses. Some are volatile and can be lost to evaporation, especially from wet soil (see Table 3).

Table 3. 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

* Volatility varies significantly depending on soil moisture and temperature at the time of application and immediately after. As both soil moisture and temperature increase, so does the rate of volatilisation. Even so-called non-volatile herbicides such as atrazine can lose up to 12% through post-application volatilisation. For soil applied herbicides prone to volatilisation such as trifluralin, triallate and pendimethalin, volatilisation can significantly reduce efficacy, particularly if not quickly incorporated.

It is important to understand the water solubility of each of the pre-emergent herbicides, as this not only affects crop safety (how the herbicide may wash into various areas of the seedbed), but it also affects the amount of rainfall required to activate the product. In general the higher water soluble a herbicide is, the less rainfall required for activation. Water solubility can also affect the residual activity of a herbicide, where highly water soluble products are usually less residual (e.g. Logran®), however this relationship is not always consistent. A good example of this is with Balance®, where each rainfall activity reactivates the herbicide.

Principles of incorporation

The method of incorporating pre-emergent herbicides in conservation farming systems is much different than what was done in a conventional system which includes cultivation.

Traditionally, pre-emergent herbicides such as trifluralin were applied to a cultivated seedbed and incorporated in a separate process by cultivation or harrowing up to 4 weeks before sowing. This system only allowed for low rates of herbicides to be used, and crop damage was common as the herbicide was mixed throughout the seedbed, and commonly in direct contact with crop seed.

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 seed bed 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 conversely 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 aiming 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. The principle of IBS aims to:

(a) *Minimise soil disturbance* to limit soil moisture losses and limit seed burial to depth. Leaving weed seeds on the soil surface exposes them to sunlight, insect predation and is the best target site for pre-emergent herbicides. Most of these pre-emergent herbicides work predominantly by root uptake as shown in Table 3, 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.

(b) *Throw soil in between rows but not onto neighbouring rows*. This 'hot bed' of herbicide treated soil on the inter row (in between seed rows) forms a concentrated layer of herbicide which increases weed control. It also minimises herbicide or herbicide treated soil washing back into the seed furrow. In addition, drying of the soil surface where weed seeds lie is minimised, as it is now buffered by a layer of freshly thrown soil. This is important as pre-emergent herbicides need moisture to activate.

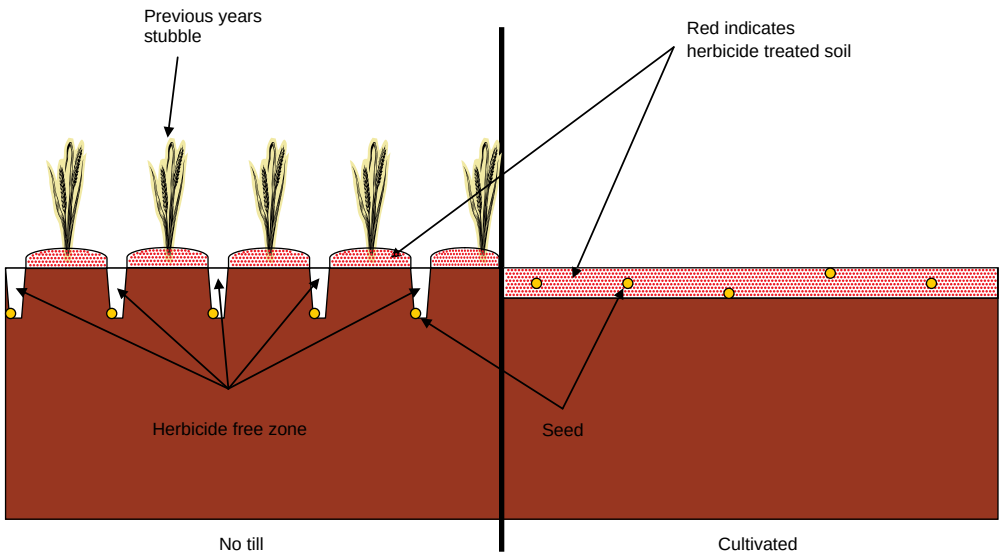
(c) *Leave the seed furrow free of herbicide treated soil*. This allows the crop to emerge from a micro environment free of herbicide, maximising crop establishment and vigour. The negative is that in high weed pressure situations, weeds can emerge in the row. Crop competition usually limits the effect that these weeds establishing in the plant row have on yield.

(d) *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. It is extremely important that seed depth is uniform and the seed furrow is closed and filled with an even amount of herbicide free soil. 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.

(e) *Minimise the impact* of water soluble herbicides washing off site and causing environmental issues during heavy rain events.

(f) *Minimise the exposure of herbicides to animals, insects and birds*, as the herbicide is buried beneath the soil surface shortly after application.

Figure 1. Illustration of the difference between using pre-emergent herbicides in an IBS no till scenario and fully cultivated scenario.



Preparing your seedbed for pre-emergent herbicides

It is essential to be planning and preparing your seedbed well before sowing to ensure that you get the most from your pre-emergent herbicides. This is the case with all products.

This preparation begins at harvest, where you should aim to spread trash as evenly as possible across the width of the header. This will be discussed in more detail later, and is vitally important to allow your pre-emergent herbicides to work effectively, as many will not work if applied to high trash loads.

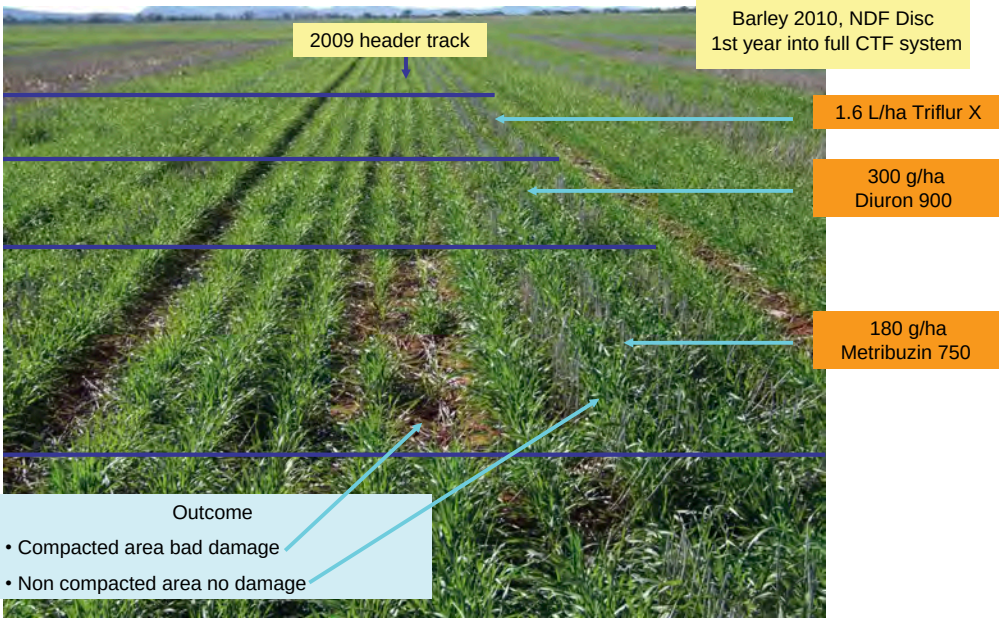
Secondly, both during the harvest process and in later weed control passes, it is essential that you limit uncontrolled traffic across your paddock. Traffic does two things: flattens stubble limiting soil contact of herbicides, and causes soil compaction. If your soil is compacted, pre-emergent herbicides can concentrate in these compacted areas causing crop damage following rainfall. This is particularly worse with highly water soluble products when rainfall occurs directly after sowing. Compacted areas of a paddock will also cause issues with seeder penetration, and consequently seeding depth will often be shallower or inconsistent. Shallow seeding increases crop exposure to pre-emergent herbicides and consequently increases crop damage.

Thirdly, it is essential to have your seedbed weed free when applying your pre-emergent herbicides. This may mean applying a knockdown a few weeks before sowing, which is good practice in any case as valuable soil moisture and nutrients can then be retained for the emerging crop.

Weeds present in the seedbed when spraying pre-emergent herbicides cause two main issues:

(a) Weed leaves intercept the herbicide restricting its contact with the soil, and hence reduced soil residual activity. Established weeds will also take up some of the pre-emergent herbicide through their roots, leaving less behind for residual weed control in the following crop.

Figure 2. The result of compaction in a trial at Rankins Springs, 2010. Note the damage with metribuzin is only observed in the compacted wheel track. Seed depth in this example was consistent across the seeder.

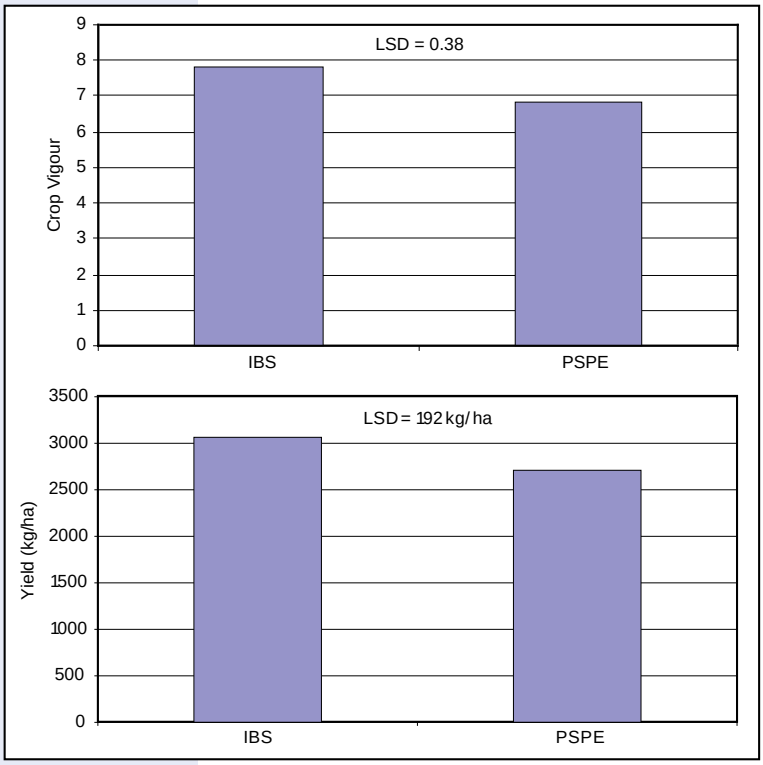


* Metribuzin and diuron are not registered for use in barley in NSW.

(b) Weeds wrap around sowing tynes, which in turn widens the width of the knife point, increasing soil throw into neighbouring rows and widening the sowing furrow. A wider sowing furrow will therefore contain less herbicide and weed escapes will be common.

Figure 3. Weeds present at sowing can wrap around tynes, widening the tyne width and furrow.

Figure 4. The average of crop safety and yield in IBS and PSPE across a number of pre-emergent herbicide trials in 2010 and 2011. Note 0 = No crop vigour, 10 = vigorous.



IBS vs PSPE

Many herbicides are registered for either IBS, PSPE or a combination of both. Trials conducted in NSW clearly show crop safety advantages when applying pre-emergent herbicides and then incorporating them by sowing rather than applying them post sowing pre-emergent.

There are pros and cons for each method of application. When considering what will best suit your situation, consider:

(a) Herbicide labels will sometimes dictate the method of application and not allow the choice of either IBS or PSPE.

(b) IBS will nearly always be safer on crop emergence, and only involves one herbicide application pass across a paddock.

(c) IBS does leave a furrow free of herbicide which can lead to weeds establishing in the crop row. In this case consider using water soluble herbicides either alone or in a tank mix to allow some herbicide to wash into the seed furrow to provide weed control in this micro environment.

(d) PSPE strategies involve herbicide being applied to the soil surface following sowing and will rely heavily on rainfall after application to be effective. Rainfall following sowing whilst desirable is not as important in an IBS system as you are applying the herbicide directly onto weed seeds and then covering the inter row with moist soil.

Figure 5. The negative of the IBS method on seed furrow weed control with 1.8 L/ha of trifluralin. This picture highlights the lack of weed control in the furrow (also a blocked row) in a weedy paddock. This effect may have been negated by mixing a more water soluble herbicide as well such as Logran®, Boxer® Gold or Sakura®.

Figure 6. The effect of too much soil throw in an IBS system. It is important to minimise herbicide treated soil entering neighbouring furrows. In this picture you can see that increased soil throw has reduced crop emergence in every second row as a result of increased soil depth. Adding 1.8 L/ha trifluralin to this worsens establishment further.

(e) Weed seeds in a PSPE system are generally spread throughout the seed bed, making weed control more difficult. This is particularly the case where the seedbed is levelled by harrows. It is therefore important in a PSPE system to utilise both root and shoot uptake products that are non volatile and easily metabolised by your crop.

(f) In some cases in a PSPE system when rain follows application, followed by a dry spell, the soil surface may form a crust. If this crust cracks, weeds commonly germinate below the crust and establish through cracks. This is common in irrigated farming systems where soils are usually heavy clays that shrink, swell and therefore crack.

Figures 7 and 8. The impact on the emerging seedlings from Figure 6 in affected rows. This is typical trifluralin damage, showing a swollen coleoptile and 'scissor' leaf.

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:

(a) 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.

(b) 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.

Figure 9. Performing trials on pre-emergent herbicides into very heavy stubble. This system relies on GPS guidance, higher water rates, large droplets and higher label rates of herbicide.

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

(d) 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 4.

(e) 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.

If stubble loads are too high, as a last resort (but an effective tool as part of an integrated weed management approach), burning either windrows or whole paddocks may be an option.

Following burning concentrations of ash, particularly in the old seed furrows, can be common. This ash can bind to herbicides in a manner similar to how herbicides bind to stubble, and in turn de-activate a proportion of the herbicide. More importantly, herbicide applied to ash may be blown into seed furrows or offsite during windy conditions. This either concentrates herbicide into specific areas of the seedbed, or reduces the amount of herbicide in the paddock and potentially causes environmental issues in surrounding areas (the same can occur when applying pre-emergent herbicides to paddocks recently limed).

Aiming for warmer burns a few weeks or months before sowing, and waiting for a rain following the burn before spraying, will help minimise the impact of ash on pre-emergent herbicides.

Table 4. Effectiveness of common pre-emergent herbicides in high stubble load situations. Modern labels will suggest adequate control with up to 50% stubble cover.

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

Using pre-emergent herbicides with different seeding equipment

In recent years, seeders have changed dramatically in their design aiming to maximise trash flow and seed placement uniformity whilst minimising soil disturbance. This has lead to an increased uptake of knife point and press wheel seeders and more recently disc seeders.

Each seeder will create a different environment for an establishing crop, and it is essential to understand this before you use pre-emergent herbicides.

It is also essential to understand how this environment may change with IBS or PSPE incorporation methods. In general, there is a great deal of difference achieved for crop safety between seeders in IBS systems, and less difference in PSPE application methods. The PSPE technique relies on uniform seeding depth and 'flatter' seedbeds without pronounced furrows. This section focuses on the IBS method of incorporation, as typically this method is preferred in conservation farming systems.

Figure 10. This photo shows a Serafin Ultisow disc seeder and its ability to throw soil between the rows in a controllable manner. This is not achieved with all disc seeders.

Pre-emergent herbicides that are incorporated by sowing rely on the sowing process to ensure the herbicide is incorporated effectively and that the seed is placed into a micro environment that allows safe and effective germination.

In all cases, the ideal situation is using a knife point or disc followed by a press wheel.

Press wheels are essential as they provide the seed with good soil contact, and minimise the amount of herbicide treated soil from the inter row being dragged into the seed furrow. They also allow seeders to pass through stubble without the machine becoming choked with trash.

The key is to understand that all seeding gear is different which, in turn, creates varying seedbed conditions.

In tyned seeders variations include:

(a) Angle of tyne entry to the soil,
(b) Width and shape of seeding point,
(c) Breakout pressure of tyne,
(d) Depth uniformity across machine,
(e) Trash flow ability across machine, and
(f) Press wheel size and shape.

In disc seeders variations include:

(a) Ability to penetrate compacted soils,
(b) Ability to achieve controlled soil throw onto the inter row,
(c) Angle of disc entry to the soil,
(d) Size, shape and width of disc,
(e) Seed placement in furrow, i.e. bottom or side,
(f) Closing plates or closing wheels that allow consistent closure of the seed slot without returning herbicide treated soil onto the seed,
(g) Depth gauge wheel placement and size, and
(h) Press wheel angle, size and shape.

Equally important, other factors not associated with the type of seeding system also influence seed bed conditions. These include soil type, soil moisture, soil compaction, row spacings, seeding depth and sowing speed.

To ensure adequate soil throw, many people assume 1 km/hr for every 1cm of row spacing. This is incorrect, and there is no rule for soil throw, row spacing and sowing speed because of the variability discussed previously. **The only way to check for adequate soil throw is to check every scenario.**

The suitability for pre-emergent herbicides in both tyne and disc seeding systems has attracted a lot of research over the past few years. Unfortunately many herbicide labels will not support the use of some pre-emergent herbicides with disc seeders, as there is greater risk of crop damage due to varying machine designs that form very different seedbed conditions.

Irrespective of the disc seeder, research in southern NSW has clearly shown that a well set-up tyne seeder will offer greater crop safety than a well set up disc seeder. This is mostly because a knife point and press wheel will place more soil on the inter row minimising herbicide treated soil washing into the seed furrow. Soil throw in tynes is also 'better controlled', resulting in less herbicide treated soil in a typically wider furrow.

As shown in Figure 11, this research has also shown that some herbicides and rates of a particular herbicide are better suited to a disc seeder system than others. This is usually correlated with how a seedling metabolises a particular herbicide if they unfortunately come in contact with one another. From this you can see that trifluralin at higher rates is definitely not suited to disc seeding systems, as crop vigour may be adversely affected.

Figure 11. The difference in crop safety between discs and tynes across a number of commonly used pre-emergent herbicides in trials held across southern and central NSW. Various disc and tyne seeders were used for these trials. 0 = No crop vigour, and 10 = vigorous.

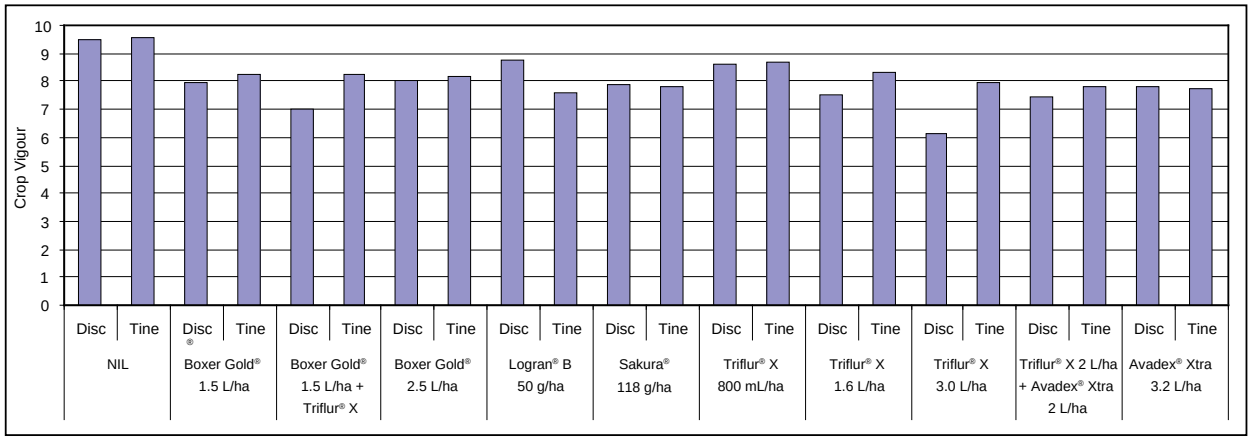


Table 5 aims to highlight the experiences gained across a number of trials since 2004. It is important to note that if a herbicide is safe on crop emergence in one situation, it may not be in the next situation, and this table tries to capture those experiences.

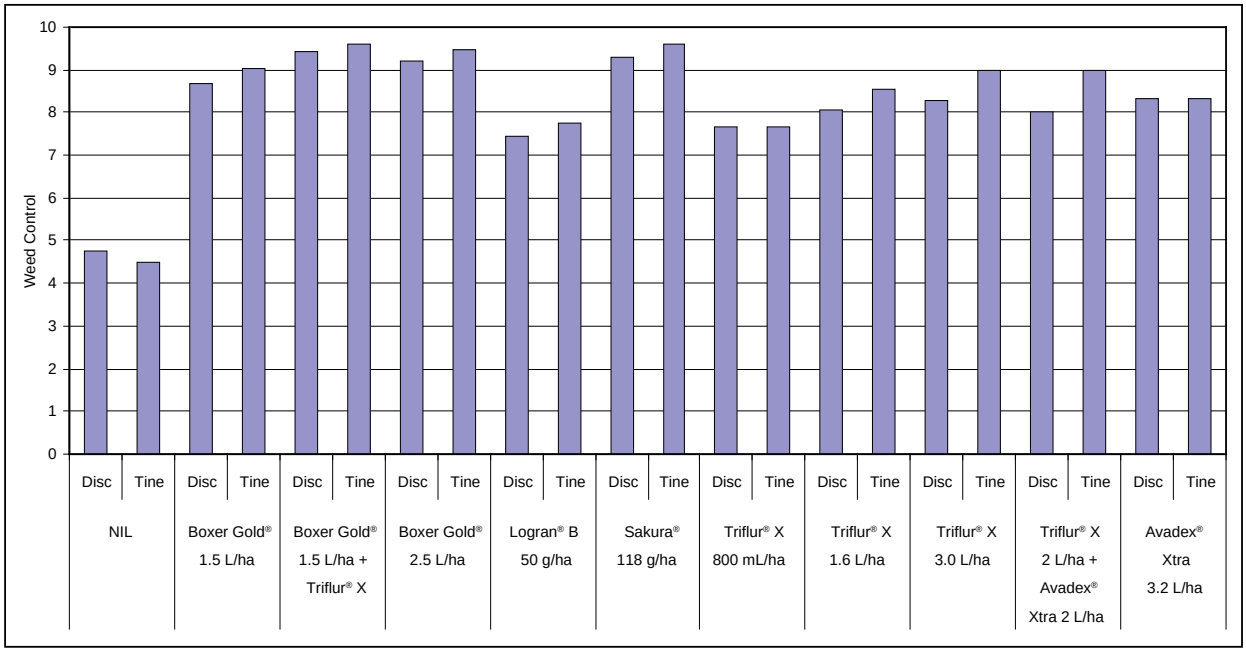
Weed control between herbicides also varied as shown in Figure 12. Across all trials there has not been any consistent measured difference in weed control between discs and tynes, although when adequate soil throw is not achieved volatile products such as trifluralin will not work as well in disc systems.

Table 5. Pre-emergent herbicide use with disc seeders – measurements and observations from trials across southern NSW since 2004.

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.

Figure 12. The difference in weed control between discs and tynes across a number of commonly used pre-emergent herbicides in trials held across southern and central NSW. 0 = No weed control, and 10 = complete weed control. Weeds were mostly annual ryegrass.



Tips for using pre-emergent herbicides with disc seeders

If you decide that you need to use a pre-emergent herbicide and you own a disc seeder there are things that you can do to maximise crop safety and weed control. These include:

(a) Aim for IBS rather than PSPE incorporation, as it is safer for your emerging crop. The exception to this is when using some herbicides on pulse crops, where PSPE is an appropriate method of application. This requires a level seedbed, limiting herbicide washing into the furrows. Level seedbeds also aid in harvest management in pulse crops.

(b) Select a herbicide and rate of herbicide that will not cause significant crop damage if conditions are not as planned. These can be seen in Table 5 and Figure 11. Be aware of label restrictions.

(c) Become familiar with your disc seeder. Only use pre-emergent herbicides in disc seeders that throw some soil on the inter row, but keep the seed furrows clean from herbicide treated soil.

(d) Be careful of closer plates and/or depth gauge wheels returning herbicide treated soil to the seed furrow.

(e) Sow seed to a minimum depth of 3 cm (soil on top of seed).

(f) Always ensure the seed furrow is closed, i.e. 'close the slot'. This is critical!

(g) Target paddocks with standing stubble and minimal chances of 'hair pinning'. Hair pinning involves the disc rolling on top of stubble and/or weeds rather than cutting through it, which causes variable seed depth and consequently greater crop damage.

Figure 13. Not 'closing the slot' is one of the most likely scenarios that will cause significant crop damage, as the herbicide washes into the seed furrow and onto the seed following rainfall. Weeds that are present at sowing obviously have live root systems which make closing the slot much more difficult than if the paddock is free from weeds at sowing.

Figures 14–16. Seedbeds vary between different disc seeders. Amity Drill , Serafin Ultisow and John Deere respectively.

Residual effect of pre-emergent herbicides

It is very common for pre-emergent herbicides to provide weed control well into the winter and, in some cases, throughout the crop and into the fallow period. This effect has been noticeably beneficial of late with fleabane control into the summer fallow following a crop that has had herbicides such as Terbyne®, simazine, Balance®, metribuzin, Glean® or Logran® applied pre sowing.

Trifluralin and diuron are also known to provide some control of black/stink grass (*Eragrostis* spp.) into the summer fallow.

Unfortunately controlling fallow weeds with pre-emergent herbicides at sowing is very unreliable, and should be considered a bonus rather than something that would be relied on.

On-going weed control is a function of the persistence (commonly measured as half-life) of the herbicide and its residual impact on weeds.

Figure 17. Achieving a consistent depth of at least 3 cm is critical for even emergence and allows a small buffer if herbicides do wash into the furrow.

Soil half-lives are only an indicative guide and are not the sole measure of residual weed control. For example many herbicides may have a long half life, but have poor extended residual weed control as their bioavailability to weed seeds and/or efficacy at low concentrations is low. Some products as they break down also produce secondary metabolites, which may also aid in weed control. This process is variable and complex.

What is a half life?

The half-life of a herbicide is the time it takes for 50% of the chemical to degrade or break down in soil. From Table 6, it can be seen that diuron has an average half life of 90 days. So, after 90 days, only half of what was applied will remain. After 180 days, 50% of the original amount will have decreased by half again, so only 25% will remain. And so on.

Half-life varies with soil type. There is not data for all soil types and the half-life may be expressed as a range or an average. Within soil types, half-lives are affected by pH, temperature, moisture content, sunlight and concentration of active ingredient. Higher temperatures, greater soil moisture, high biological activity and high levels of organic matter tend to accelerate degradation; dry and cold conditions tend to lengthen degradation. **In NSW, dry or drought conditions are the main factor in causing herbicide residues to persist longer than normal.**

What is residual?

Some herbicides have a long residual. The residual is NOT the same as the half-life. Although the amount of chemical in the soil may break down to half the original amount rapidly, what remains can be persistent for long periods, e.g. sulfonyl ureas (chlorsulfuron). This is shown in the table where known. Herbicides with long residuals can affect subsequent crops, especially if they are effective at low rates of active, like the sulfonyl ureas. On labels, this will be shown by plant back periods, which are usually listed under a separate plant back heading or under the 'Protection of crops etc' heading in the General Instructions section of the label.

Table 6. Residual persistence of common pre emergent herbicides, and noted residual persistence in broad acre trials and paddock experiences.

Herbicide	Half life (days)	Residual persistence and prolonged weed control
Logran® (triasulfuron)	19	High. Persists longer in high pH soils. Weed control commonly drops off within 6 weeks.
Glean® (chlorsulfuron)	28–42	High. Persists longer in high pH soils. Weed control longer than Logran®.
diuron	90 (range 1 month to 1 year, depending on rate)	High. Weed control will drop off within 6 weeks, depending on rate. Has had observed long lasting activity on grass weeds such as black/stink grass (*Eragrostis* spp.) and to a lesser extent broadleaf weeds like fleabane.
atrazine	60–100, up to 1 year if dry)	High. Has had observed long lasting (> 3 months) activity on broadleaf weeds such as fleabane.
simazine	60 (range 28–149)	Med/High. 1 year residual in high pH soils. Has had observed long lasting (> 3 months) activity on broadleaf weeds such as fleabane.
Terbyne® (terbulthylazine)	6.5–139	High. Has had observed long lasting (> 6 months) activity on broadleaf weeds such as fleabane and sow thistle.
Triflur® X (trifluralin)	57–126	High. 6–8 months residual. Higher rates longer. Has had observed long lasting activity on grass weeds such as black/stink grass (*Eragrostis* spp.).
Stomp® (pendimethalin)	40	Medium. 3–4 months residual.
Avadex® Xtra (triallate)	56–77	Medium. 3–4 months residual.
Balance® (isoxaflutole)	1.3 (metabolite 11.5)	High. Reactivates after each rainfall event. Has had observed long lasting (> 6 months) activity on broadleaf weeds such as fleabane and sow thistle.
Boxer Gold® (prosulfocarb)	12–49	Medium. Typically quicker to break down than trifluralin, but tends to reactivate after each rainfall event.
Sakura® (pyroxasulfone)	10–35	High. Typically quicker breakdown than Trifluralin and Boxer Gold®, however weed control persists longer than Boxer Gold®.

Sources: Tomlinson, C D S, ed, *The Pesticide Manual*, 15th ed, Farnham, British Crop Protection Council, 2009;
Extoxnet, http://extoxnet.orst.edu/;
California Dept Pesticide Regulation Environmental Fate Reviews, www.cdpr.ca.gov/docs/emon/pubs/envfate.htm
APVMA Public Release Summaries and Chemical Reviews, www.apvma.gov.au

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The information contained in this publication is based on knowledge and understanding at the time of writing (April 2012). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of the NSW Department of Primary Industries or the user's independent adviser.

Always read the label

Users of agricultural chemical products must always read the label and any Permit before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the Permit by reason of any statement made or not made in this publications.

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