

HERBICIDE BEHAVIOUR FACT SHEET

Rotational constraints for pulse crops following the use of aminopyralid, clopyralid and picloram herbicides

Herbicides from the Group I Mode of Action are effective knockdown herbicides against many broadleaf weeds. However, care must be taken as several have significant soil residual properties with implications for rotational crops.

The potential for residual effects causing crop injury to following pulse/legume crops in the crop sequence is particularly high with some herbicides from the pyridine sub class of Group I herbicides. Their capacity to persist and damage subsequent crops is complicated by how these herbicides persist in crop residues.

THERE ARE SEVERAL HERBICIDE SUB-CLASSES WITHIN THE GROUP I MODE OF ACTION GROUP.

Sub-class	Examples of herbicides
Arylpicolinate	halauxifen (e.g. Arylex [®] active herbicides) florpyrauxifen (e.g. Ubeniq [®])
Benzoic acids	dicamba (e.g. Kamba [®])
Phenoxy	2,4-D, 2,4-DB, MCPA, MCPB
Pyridines	aminopyralid (e.g. Hotshot [®] , also contains fluroxypyr) clopyralid (e.g. Lontrel [®]) fluroxypyr (e.g. Starane [®]) picloram (e.g. Tordon [®]) triclopyr (e.g. Garlon [®])



Sub-lethal picloram damage to faba beans appears as upwards cupping of leaves.

How do Group I herbicides work within the plant?

Group I herbicides mimic the naturally occurring plant hormone indole-3-acetic acid (IAA).

IAA plays a critical role in managing division, differentiation and elongation of plant cells. Changes in concentration within a cell signal for a growth response in roots and particularly shoots. In addition, changes in IAA concentration also play a role in controlling seedling morphology, apical dominance, leaf senescence and many processes at a whole plant level including abscission, flowering and fruit production (Congreve & Cameron 2018).

Concentration of IAA within the cell must be highly regulated by the plant. For example, when cell elongation is required, the concentration of IAA within the cell will increase. After the required elongation has occurred the plant will downregulate (switch off) IAA production, causing the concentration to fall.

Group I herbicides mimic this growth regulation function of IAA, although they are not able to be downregulated by the plant, as is the case with naturally occurring IAA. Following exposure to Group I herbicides, a cascade of unregulated growth occurs within susceptible plants, leading to rapid stem and leaf distortion and eventually plant death. At sub-lethal concentrations, plant symptoms in susceptible species typically appear as cupping of the leaf margins and leaf vein thickening, especially on new growth, with downward twisting, curling and corky growth in stems.

Why use pyridine herbicides in grain cropping?

At labelled crop timing and application rates, pyridine herbicides have acceptable post-emergent tolerance to winter cereal crops, allowing selective, in-crop weed control of many broadleaf weed species. In addition, clopyralid is also able to be used post-emergent in canola without damage.

These herbicides can be used for broadleaf weed control in fallow situations, when appropriate plant-back periods are implemented.

Depending upon application rate, aminopyralid, clopyralid and picloram will provide some level of extended residual persistence in the soil and may provide control of subsequent weed germinations. This extended residual control is often a key reason why these pyridine herbicides may be chosen over another Group I herbicide. For example, for residual control of weeds such as fleabane.

How are pyridine herbicides degraded?

The primary pathway for degradation of these herbicides upon reaching the soil is via microbial activity. Little microbial activity occurs during cold winter months. Microbial populations near the soil surface build rapidly as temperatures start to rise in spring, provided there is adequate soil moisture. Without adequate soil moisture in the soil profile (in particular in the top 10cm) there will be little, or no, microbial degradation.

Fluroxypyr, triclopyr, dicamba and the phenoxy's have relatively short soil persistence over the summer months, provided the soil is moist to support



PHOTO: MARK CONGREVE

Retaining stubble or concentrating stubble for chaff lining may see accumulation of aminopyralid, clopyralid or picloram residues which may adversely affect following sensitive crops such as pulses.

microbial degradation (although plant-back periods do exist for certain crops). Dry soil can result in significantly longer safe replanting times.

Herbicides containing aminopyralid, clopyralid or picloram are known to persist under certain circumstances, with implications for rotational crops – in particular pulse crops, lucerne and annual pasture legumes (e.g. clovers, medics).

Labelled plant-back constraints typically require several months before susceptible crops can be planted. More recent labels include minimum rainfall requirements within this time period.

Under heavy rainfall, some herbicide may be lost due to runoff or leaching deeper into the soil profile, although this should not be relied upon as a dissipation method. Losses from volatility or photodegradation are negligible.

When these herbicides are applied post-emergent to an established crop (e.g. applications in winter cereals), some of the applied herbicide will be taken up by the crop and weeds and may be subsequently metabolised. The amount of herbicide intercepted by the crop will depend upon the ground cover of the crop at the time of application. Early applications (i.e. just prior, or at the start, of tillering) may result in most of the herbicide contacting the soil, as there is likely to be minimum ground cover.

Applications to advanced tillering crops may capture a high percentage of the herbicide, with less herbicide reaching the soil.

How pyridine herbicides carry over in soils

Herbicide in the soil near the surface is degraded by soil microbes, providing there is adequate soil moisture over the warmer months. Where environmental and soil conditions do not support degradation, herbicides containing aminopyralid, clopyralid or picloram can persist for many months and possibly into the next cropping phase. Extensive plant-back directions are included on the most up to date product labels.

These herbicides can be mobile in the soil, especially in sandy or light soils with low organic matter. Following rainfall, some herbicide may move deeper into the soil profile. Herbicide that has moved deeper in the soil profile may take significantly longer to dissipate as there is often less microbial activity deeper in the profile.

Where these herbicides have moved deeper in the profile, the following crops may establish adequately as microbial degradation has occurred in the topsoil, with herbicide symptoms only appearing later in the crop when roots have reached herbicide present at depth.

Soils with sub-soil constraints at depth (e.g. plough pans, substantial change in soil horizon etc.) may see herbicide accumulate above these barriers. These soils can be particularly problematic.

How pyridine herbicides carry over in crop residues (stubble)

When applied post-emergent in winter cereals, herbicide taken up by the crop

is slowly metabolised over time. It is possible that all herbicide within the crop is not fully metabolised before the crop hays off, and metabolism ceases. The concentration of pyridine herbicide within the winter cereal at the commencement of senescence will be a factor of application rate, crop size at application (amount of herbicide capture), length of time since application, seasonal growing conditions and growth dilution.

Further degradation of active herbicide in the stubble following harvest will be insignificant until the stubble decomposes in following seasons, at which time the herbicide is released back into the soil where microbes can access it. This release of herbicide back into the soil following stubble decomposition is often a contributing factor in damage to pulse crops that are grown in the year following pyridine applications in cereals.

Flaxleaf fleabane (*Conyza bonariensis*) – A case study

In recent years, fleabane has become a widespread weed of many cropping paddocks across Australia. Fleabane is a surface germinator, well adapted to zero till farming systems. It germinates in large numbers in spring and autumn in many regions and hence can establish in the winter crop phase.

Fleabane that has not been controlled in the winter crop is likely to develop an extensive tap root and will be very difficult to kill with knockdown herbicides after harvest, especially where the plant tops are removed during the harvest operation.

Several Group I herbicides can provide effective knockdown control of fleabane in winter cereals. Pyridines with extended residual control (i.e. herbicides containing aminopyralid, clopyralid or picloram) can also provide some extended control of spring fleabane germinations, so the use of these herbicides has become very popular in recent years (Brill et. al. 2012) (Welsh and Plater 2014).

The use of residual pyridine herbicides to achieve control of spring germinating fleabane can be associated with increased damage to pulse crops grown the following year where conditions have not been adequate for herbicide breakdown.

Application rate, timing and length of residual control

Maximum application rates of aminopyralid, clopyralid or picloram herbicides used in winter cereals have been established to ensure acceptable crop selectivity.

To provide robust knockdown and optimise the length of residual control into spring, the application rate for fleabane control is generally at, or close to, the maximum registered rate for in-crop use. For clopyralid, the full label rate registered for cereals is recommended, which is higher than rates typically used in common tank mixes. High application rates are likely to increase the chance of rotational crop issues where susceptible crops are grown the following season.

Users seeking to maximise residual control into the spring may wish to delay application until the latest registered crop growth stage, on the assumption that this will result in the longest period of residual control. However, this is often not the case. Applying these herbicides later results in more of the herbicide being intercepted by the crop or weeds present at application, and less herbicide reaching the soil, where it is required for residual weed control.

These later applications result in more herbicide entering the cereal crop and less time for the herbicide to be

metabolised before the crop hays off. This results in higher levels of herbicide present in stubble and the potential for more impact on sensitive rotational crops as the stubble decomposes.

Trials have shown that applications applied earlier (i.e. early tillering where there is a lower percentage of crop cover) often results in better long-term control.

A preferred strategy is generally to apply earlier in the crop (i.e. early tillering) where the crop and weeds are small. This results in more effective knockdown of existing weeds and better residual control, as more herbicide reaches the soil surface where it is required. The herbicide intercepted by the crop will also have longer to be metabolised and be subject to substantial crop growth dilution. Residues in the stubble are likely to be considerably less following early application.

If a pulse crop is likely to be planted the following year then stubble should also be removed or incorporated soon after harvest.

Fleabane control using Tordon® 242 (1 L/ha) + metsulfuron (5 g/ha) applied at two application timings in wheat. (Northern Grown Alliance 2012).

Location (trial no.)	Application date	Crop growth stage	% control v untreated (in-crop measurement)	% control v untreated (after harvest)
Pilliga (AM1208)	T1 7/8/12	GS 30-33	100%	100%
	T2 25/9/12	GS 39	84%	85%
Bowenville (RD1205)	T1 24/7/12	GS 31	99%	97%
	T2 7/8/12	GS 32	91%	62%
North Star (RM1217)	T1 15/6/12	GS 12-13	82%	trial abandoned due to drought
	T2 24/7/12	GS 31	68%	

Techniques that help to reduce this risk are recommended on several product labels. More recent product labels for aminopyralid, clopyralid and picloram herbicides contain directions in relation to stubble management, to avoid stubble from treated crops containing herbicide residues from affecting subsequent susceptible crops.

For example, the Lontrel® Advanced label states:

Stubble from treated crops – ensure that harvesters effectively spread crop straw and do not leave a heavy 'header trail' after harvest. Burn (if legal in the area), bale and remove, slash or incorporate stubble as soon as practical after harvest and as long as possible before planting next year to allow microbial breakdown of any residues in straw. Heavy stubble loads may carry more residues into the following season.

Strategies that help avoid carry-over issues to sensitive crops

Extensive plant-back information can be found on individual product labels which can be accessed from the APVMA PubCRIS website <https://portal.apvma.gov.au/pubcris>

The GRDC publication **Rotational crop constraints for herbicides used in Australian farming systems** also provides detailed information on plant-back constraints www.grdc.com.au/rotational-crop-constraints-for-herbicides

Where a winter cereal crop was treated with an aminopyralid, clopyralid or picloram based herbicide and stubble is retained and/or there has not been adequate soil moisture over the warmer months for microbial degradation, the safest approach is to grow a cereal or canola crop the following year.

In situations where aminopyralid, clopyralid or picloram herbicides are to be used in the winter cereal it is likely that a pulse crop may be grown the following season, it is recommended to apply the pyridine herbicide as early as practical in the winter cereal crop, so as to allow the maximum length of time for herbicide metabolism and growth dilution. In addition, remove or incorporate stubble immediately after harvest, and monitor spring/summer rainfall to ensure this is adequate for microbial decomposition.

Some labels suggest conducting a field or pot bioassay, whereby seeds of the rotational crop are planted into soil suspected to contain herbicide residues. Bioassays can help determine the likelihood of successful emergence, however care should be taken as bioassays may not adequately address herbicide residues located deeper in the soil profile or may not account for herbicide being subsequently released from degrading stubble.

Instructions for conducting a pot bioassay can be found here <https://www.agronomo.com.au/latest-news/https://www.wagronomocomau/latest-news-2>

MORE INFORMATION

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FURTHER RESOURCES

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