Deployment of Group 14 herbicides into broadacre weed management systems in the northern cropping belt. How they work, what affects performance and where do they fit?

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Key words

herbicides, post-emergence weed control, pre-emergence weed control, fallow, pre-harvest

Take home message

Group 14 herbicides provide a useful tool in northern farming systems particularly in providing an additional mode of action for pre-emergence weed control and giving useful knockdown control of a range of broadleaf weeds. Care must be taken in including Group 14 herbicides with glyphosate when targeting summer grasses in particular.

Introduction

Group 14 herbicides are inhibitors of the protoporphyrinogen oxidase (PPO) enzyme. In post-emergence applications, the absorbed herbicide inhibits PPO located in the outer envelope of plant chloroplasts causing the protoporphyrinogen (protogen) precursor to leak out into the cytoplasm. The precursor is converted to protoporphyrin IX (proto). In the presence of light, proto generates production of reactive oxygen species (ROS) that react with membrane lipid and cause lipid peroxidation (Barker *et al.,* 2023).

The first patent for a PPO herbicide was issued to Rohm & Hass in 1963 (nitrofen). The earliest commercialisation of PPO herbicides in Australia occurred in the 1970s with the introduction of oxadiazon (Ronstar®) followed later by oxyfluorfen (Goal™) and acifluorfen (Blazer®). Table 1 provides a summary of the Group 14 herbicides currently registered for use in Australia.

Table 1. Group 14 herbicides

Active ingredient	Group	Use pattern	Example tradenames
Oxyfluorfen	Diphenyl ether	'spike' Pre-emergent	Goal™
Acifluorfen	Diphenyl ether	Selective post	Blazer®
Fomesafen	Diphenyl ether	Pre-emergent	Reflex®
Oxadiazon	N-phenyl-oxadiazolones	Pre-emergent	Ronstar®
Carfentrazone	N-phenyl-triazoliones	'spike' Selective post	Hammer® Affinity®
Flumioxazin	N-phenyl-imides	'spike' Pre-emergent	Valor® Terrain®
Butafenacil	N-phenyl-imides	'spike'	B-Power®
Saflufenacil	N-phenyl-imides	'spike'/PRE	Sharpen®
Tiafenacil	N-phenyl-imides	'spike'	Terrad'or®
Trifludimoxazin	N-phenyl-imides	'spike'/PRE Pre-emergent	Voraxor®
Pyraflufen-ethyl	phenylpyrazoles	'spike' Selective post Defoliant	Sledge®

Apart from the use of acifluorfen (Blazer®) in soybean and peanuts, early developments of Group 14 herbicides in broadacre uses surrounded the addition of oxyfluorfen to glyphosate in order to enhance speed of burndown of weeds more generally relative to glyphosate alone. Apart from small-flowered mallow, no additional weed control was generally observed and, in some instances, reduced long-term knockdown weed control was recorded.

Physical characteristics

As foliar treatments, PPO inhibitor herbicides are generally not strongly translocated though saflufenacil is reported to have some limited translocation. Activity is strongly mediated by the presence of light with higher light intensity bring about more rapid activity. For this reason, antagonism of activity with glyphosate is greater under conditions of high light intensity.

Use patterns

PPO inhibitor herbicides are widely deployed in northern farming systems, and this has increased in recent years with expanding registration for flumioxazin, saflufenacil, saflufenacil + trifludimoxazin and tiafenacil.

1. Selective post-emergence herbicides

Acifluorfen (Blazer) has been registered for control of selected broadleaf weeds for over 40 years though the high cost and limited number of suitable crops (including soybean, peanuts and mungbean) has limited the widespread use of this product. The use of Hasten spray adjuvant at the lower rate of application has made the use of acifluorfen (Blazer®) more attractive in mungbean. Acifluorfen has demonstrated variable activity in more semi-arid environments away from coastal regions. Herbicide performance is enhanced under higher humidity conditions and can be quite ineffective when hot and dry conditions prevail.

2. Selective pre-emergence herbicides

While flumioxazin (as Valor or Terrain) is registered for at-planting pre-emergence application of up to 140 gai/ha in soybean, peanuts, at up to 90 g ai/ha in chickpea and faba bean and up to 60 gai/ha prior to planting wheat (excluding durum), application in fallow at rates of the 140 ga/ha either alone or in combination with s-metolachlor (prior to planting in sorghum at least 1 month prior to planting) has become increasingly popular. Flumioxazin is quite stable on the soil surface, has low solubility and therefore is particularly effective against most surface germinating weed species such as fleabane, sowthistle and Feathertop Rhodes grass. Effectiveness against deeper germinating weeds can be variable where emergence occurs while the surface is dry.

saflufenacil + trifludimoxazin (Voraxor) is currently registered as both a knockdown treatment (100 mL/ha + methylated seed oil) alone or in combination with glyphosate or paraquat prior to planting; or at the higher rate of 200 mL/ha 0-7 days prior to the planting of winter crops (wheat, durum, barley, oats, triticale, chickpea, faba bean, field pea) and at 240 mL/ha 7-21 days prior to planting (wheat, barley, durum, oats, triticale only). As treatments require displacing treated soil away from the planted furrow with a tyned based system common in southern Australia, saflufenacil + trifludimoxazin (Voraxor) has not been widely used to date in northern farming systems. Pre-emergence activity against a wide range of broadleaf weeds including black bindweed (climbing buckwheat), wireweed, turnip weed, wild radish, sowthistle and fleabane offers a clear alternative to the current reliance on post-emergence treatments.

3. Selective or shielded application

At present, only flumioxazin is registered for use as a shielded application providing knockdown and pre-emergence weed control in cotton. While flumioxazin is not translocated, incidental contact with the leaves and lower stem of cotton, excessive foliar contact or contact with green stems can be very damaging to the cotton plant. Flumioxazin has been quite effective in providing knockdown control of *Ipomea* spp. and other weeds between cotton rows.

4. Spike with glyphosate or paraquat

Many PPO inhibitor herbicides are registered at relatively low application rates for use as a 'spike' with glyphosate or paraquat containing products. In the case of glyphosate, increased speed of burndown and increase in efficacy on hard-to-kill broadleaf weeds are the main justification for inclusion as tank mix partners.

Control of small-flowered mallow is claimed for nearly all PPO inhibitor herbicides approved for use in this application though realistically, control can only be consistently achieved for mallow up to the 4 to 6 leaf stage that has not been subject to a prior application with glyphosate. Other weeds that show useful enhancement for control include sowthistle (not pyraflufen), fleabane (saflufenacil and saflufenacil + trifludimoxazin), bladder ketmia and cowvine (peachvine). Usefulness of Group 14 herbicides as a spike with glyphosate may be offset by reduced grass control particularly for summer grasses.

Addition of PPO inhibitor herbicides having foliar activity with paraquat may increase reliability of control. Three examples include turnip weed, wild radish and cowvine (peachvine). PPO herbicides as a rule are more complementary with paraquat in that no reduction in activity of paraquat is expected and, in some instances, an enhancement of activity on grasses has been demonstrated (e.g. tiafenacil, saflufenacil + trifludimoxazin).

5. Residual use in fallow

Flumioxazin (Valor and Terrain) is registered for fallow use at rates up to 210 - 280 g/ha (500 g/kg formulation) and 220 – 290 mL/ha for the 480 g/L flowable formulations of the same brand providing broad-spectrum pre-emergence weed control prior to planting. Not all weeds are susceptible including some grasses common in northern farming systems e.g. liverseed (urochloa) grass. Label instructions do not provide for tank mixes with other pre-emergence herbicides in this use pattern, knowledge gaps exist surrounding the value of these for growers to expand the weed spectrum controlled.

6. Pre-harvest aids

Pre-harvest use of saflufenacil (Sharpen only) in field pea, faba bean, chickpea, lentil and lupin (+glyphosate or paraquat) and mungbean and soybean (+glyphosate or diquat) is approved, with the benefit of enhancing crop dry down and achieving late season weed control. In addition, saflufenacil (Sharpen) is registered as a late-season treatment in wheat, barley and triticale as a late season salvage application of certain weeds including sowthistle when applied from the watery ripe stage.

Pyraflufen (Sledge) is recommended for use as a harvest aid in cotton assisting in leaf drop and is particularly useful under cooler conditions. Other PPO herbicides have harvest aid applications in cotton outside of Australia but have not been developed here.

Resistance

Resistance to PPO inhibitors was first reported in 2001 in the USA. Resistance has been common in the genus Amaranthus in both USA and South America. This likely reflects the widespread use of PPO herbicides in soybean as post-emergence treatments. Another feature of resistance to PPO inhibitors is the frequency of multiple resistance particular to ALS and EPSPS (Barker *et al.,* 2023). To date, resistance to PPO herbicides has not been reported in Australia.

The current practices of using PPO herbicides in mixtures either as pre-emergence or post-emergence treatments will mitigate the selection of herbicide resistant populations. However, use of PPO inhibitor herbicides in combination with glyphosate may have the effect of more quickly shifting already marginally susceptible populations to those which are more highly resistant to this mode of action.

The future

PPO resistant crops have been developed but are not yet commercialized. Tolerance to PPO herbicides will be useful in achieving sustainability of weed control practices but may be problematic for the control of crop volunteers particularly as an increasing number of resistance traits are integrated into the genome of crops where this technology is deployed.

Potential exists for the development of pre-emergence fallow uses with PPO herbicides with significant pre-emergence activity building on current in-crop uses.

References

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