Fitting new pre-emergent chemistries in the farming system and managing them for longevity

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Take home message

- New pre-emergent herbicides are becoming available; however, it is vital that these are used appropriately to get the best results
- Choice of herbicide should consider soil type, seeding system, soil organic matter and likely rainfall after application
- Non-chemical tools such as crop competition, hay and harvest weed seed control are vital to protect the longevity of new and existing chemistry
- Ryegrass blowouts in 2020 will drive the adoption of WeedSmart Big 6 tactics to manage seedbanks over the medium to longer term.

Resistance to pre-emergent herbicides in south-eastern Australia

Pre-emergent herbicides have become more important for the control of grass weeds, particularly annual ryegrass, in the past decade as resistance to post-emergent herbicides has increased. Resistance to trifluralin is now common across many cropping regions of South Australia and Victoria, and is increasing in NSW. Worryingly, resistance to the Group J and K pre-emergent herbicides can also be detected in random weed surveys. In some parts of South Australia and Victoria, resistance to triallate is becoming common. It is likely resistance will further increase, making it more difficult to control annual ryegrass with the current suite of herbicides available. New pre-emergent herbicides offer an opportunity to expand the suite of products that can be rotated. However, it is important that these are used well to optimise performance while also maintaining their longevity.

New pre-emergent grass herbicides

Several new pre-emergent herbicides have recently been released or will be released in the next few years for grass weed control. The main characteristics of these herbicides are provided in Table 1. As with previous introductions of pre-emergent herbicides, it is important to understand their best use in different environments and farming systems. Some of these products will be new modes of action, which will provide an opportunity to manage weeds with resistance to existing herbicides. However, it will be important to rotate these new herbicide modes of action to delay resistance.

Table 1. Characteristics of new pre-emergent herbicides for grass weed control

Herbicide	Devrinol®-C	Luximax®	Overwatch®	Ultro®	Mateno® Complete[a]
Active ingredient	Napropamide	Cinmethylin	Bixlozone	Carbetamide	Aclonifen + pyroxasulfone + diflufenican
Mode of Action	K	T	Q	E	New + K + F
Solubility (mg L^{-1})	74	63	42	3270	1.4 (aclonifen) 3.5 (pyroxasulfone) 0.1 (diflufenican)
Binding K_{OC} (mL g^{-1})	839	6850	~400	89	7126 (aclonifen) 223 (pyroxasulfone) 5504 (diflufenican)
Crops	Canola	Wheat (not durum wheat)	Wheat Barley Canola	Pulses	Wheat

[a]Registration of Mateno Complete is expected in 2023

Devrinol-C is a Group K herbicide from UPL registered in 2019 for annual grass weed control in canola. Napropamide is not as water soluble as metazachlor (Butisan) and has less movement through the soil. Canola has much greater tolerance to napropamide compared to metazachlor, making it much safer under adverse conditions. Devrinol-C offers an alternative pre-emergent herbicide to propyzamide or trifluralin for canola.

Luximax is registered for annual ryegrass control in wheat, but not durum. It will provide some suppression of brome grass and wild oats. In our trials, control of ryegrass is as good as Sakura®. It has moderate water solubility and higher binding to organic matter in soils. It will move readily into the soil with rainfall events, but will be held up in soils with high organic matter. Persistence of Luximax is generally good, but it degrades sufficiently quickly that plant backs are 3 to 9 months. Wheat is not inherently tolerant of cinmethylin, so positional selectivity (keeping the herbicide and the crop seed separate) is important. Knife-points and press-wheels is the only safe seeding system and the crop seed needs to be sown 3 cm or deeper. Obtaining crop safety with Luximax will be challenging on light soils with low organic matter. Heavy rainfall after application can also see the herbicide move into the crop row and cause crop damage. Due to its behaviour, Luximax is not generally suitable for dry seeding conditions. Mixtures with trifluralin, triallate and prosulfocarb are good and can provide some additional ryegrass control; however, mixtures with Sakura, Boxer® Gold or Dual® Gold are likely to cause crop damage and need to be avoided.

Overwatch from FMC is a Group Q herbicide that should be available for 2021. Overwatch controls annual ryegrass and some broadleaf weeds and will be registered in wheat, barley and canola. Suppression of barley grass, brome grass and wild oats can occur. Wheat is most tolerant to bixlozone, followed by barley and then canola. The safest use pattern will be IBS with knife-points and press wheels to maximise positional selectivity, particularly with canola. Some bleaching of the emerging crop occurs often, but in our trials this has never resulted in yield loss. The behaviour of Overwatch in the soil appears to be similar to Sakura. It needs moisture to activate and has low to moderate water solubility. The level of ryegrass control in our trials has been just behind Sakura. Mixtures with other herbicides can increase control levels and in our trials in the high rainfall zones. The mixture of Overwatch plus Sakura has been very good.

Ultro from ADAMA is a Group E herbicide that will be available from 2021. Ultro will be registered for the control of annual ryegrass, barley grass and brome grass in all pulse crops. Chickpeas are the least tolerant pulse and rates are lower. Ultro provides the best control of annual ryegrass when used pre-emergent. Ultro has relatively high water solubility, so is more effective on weeds like brome grass that tend to bury themselves in the soil. Persistence of Ultro is shorter than Sakura. Knife-points and press-wheels are the preferred seeding system for IBS applications.

Mateno Complete from Bayer is likely to be available for 2023. It contains three modes of action including a new mode of action aclonifen. For ryegrass control, it will be similar to Sakura; however, it will provide more control of wild oats and brome grass and some broadleaf weed activity. It is planned to be registered for both IBS and early post-emergent use in wheat. The timing of the early post-emergent application will be similar to Boxer Gold, at the 1 to 2-leaf stage of annual ryegrass. It will require more rainfall after application than Boxer Gold does, so the post-emergent application will be more suited to higher rainfall regions.

New pre-emergent broadleaf weed herbicides

In addition to pre-emergent herbicides for grasses, there are also new pre-emergent herbicides for broadleaf weeds. The main characteristics of these herbicides are provided in Table 2.

Table 2. Characteristics of new pre-emergent herbicides for broadleaf weed control

Herbicide	Callisto®	Reflex®[a]	Voraxor®
Active ingredient	Mesotrione	Fomesafen	Trifludimoxazin + saflufenacil
Mode of Action	H	G	G
Solubility (mg L^{-1})	1500	50	1.8 (trifludimoxazin) 2100 (saflufenacil)
Binding K_{OC} (mL g^{-1})	122	50	~570 (trifludimoxazin) ~30 (saflufenacil)
Crops	Wheat Barley	Pulses	Wheat Barley

[a]Registration of Reflex is expected in 2021

Callisto is a pre-emergent Group H herbicide from Syngenta. It is registered in wheat and barley for use in IBS, knife-point press wheel seeding systems. It has strong activity on brassicas, legumes, capeweed and thistles. Wheat is more tolerant than barley and in both cases, positional selectivity is important for crop safety. Mesotrione has high water solubility and medium mobility in soils. High rainfall resulting in furrow wall collapse could result in crop damage. Callisto has moderate persistence with plant backs of only 9 months, provided 250 mm of rainfall has occurred. Callisto offers an alternative to post-emergent Group H herbicide mixtures, where early weed control is important.

Reflex is a Group G herbicide from Syngenta with expected registration in 2021. It will be registered pre-emergent and PSPE in pulse crops for control of broadleaf weeds; IBS only in lentils. It will have similar weed spectrum to Terrain®, but will likely provide better control of brassicas, sowthistle and prickly lettuce. Fomesafen has more water solubility than flumioxazin (Terrain), so will be more mobile in the soil. It does not bind tightly to organic matter. Lentils are the most sensitive pulse crop and separation of herbicide from the seed is important, particularly on light soils with low organic matter.

Voraxor, from BASF, contains the active ingredients trifludimoxazin and saflufenacil, which are both Group G herbicides. Voraxor provides broadleaf weed control and some annual ryegrass control as a

pre-emergent herbicide in wheat, durum and barley. Voraxor is a little more mobile in the soil compared to Reflex and considerably more than Terrain. Voraxor will offer a broader spectrum of broadleaf weed control compared to Terrain and more annual ryegrass control. However, annual ryegrass control will not be as good as with current annual ryegrass pre-emergent standards. This means that it will be best used where broadleaf weeds are the main problem and annual ryegrass populations are very low. The mobility of the herbicide means crop damage may occur with heavy rainfall after application. This damage can be exacerbated if some grass pre-emergent herbicides are applied as a tank mix.

Mix and rotate in diverse farming systems

An expanded range of herbicides creates opportunities for the rotation of herbicide modes of action and the ability to mix with existing chemistry. Research by Pat Tranel from the University of Illinois, USA found that resistance can be mitigated by mixing herbicides at full rates. Pat is quoted saying ”rotating buys you time, mixing buys you shots”. Peter Newman from WeedSmart expanded on the concept to recommend that we mix herbicides and rotate modes of action so that we can ”buy time and shots”.

Research by Roberto Busi from AHRI found that rotating groups alone may not substantially delay resistance occuring. However *mixing* herbicide groups can be a highly effective tactic, even on resistant populations. Rygegrass from 140 fields across 58 farms in WA were tested for susceptibility to a range of pre- and post-emergent herbicides. The testing showed that a number of ryegrass populations were resistant to individual herbicides, for example 34% of the ryegrass populations were developing resistance to trifluralin and 11% developing resistance to triallate. Yet when these two herbicides were combined in a mix, full control was achieved.

For the other pre- and post-emergent mixtures that were tested: prosulfocarb + trifluralin, pyroxasulfone + trifluralin, triallate + trifluralin, prosulfocarb + trialliate, prosulfocarb + pyroxasulfone, triallate + pyroxasulfone and butroxydim + clethodim; there was consistently less resistance to the mixture, compared to the resistance levels of the individual herbicides when applied alone.

The mix and rotate strategy will not only provide improved weed control but more importantly aids in resistance management where unpredictable patterns of cross-resistance are evolving. Even the best pre-emergent herbicides can be broken by resistance if not managed wisely.

Populations of ryegrass from the Eyre Peninsula in South Australia have recently been confirmed as resistant to all of the pre-emergent herbicides – triallate (Avadex®), prosulfocarb (Arcade®), trifluralin, propyzamide and pyroxasulfone (Sakura). These findings by the University of Adelaide have huge implications for an industry now heavily dependent on pre-emergent herbicides in no-till systems, showing they can quickly break down in the face of metabolic cross-resistance.

Repeated applications of the same herbicides in simple canola-wheat rotations has allowed ryegrass to develop metabolic cross resistance. This is in the absence of alternative tactics such as croptopping, hay, harvest weed seed control or diverse rotations which create opportunities to run down the weed seedbank.

A heavy reliance on Groups J & K (eg Avadex®, Boxer Gold, Sakura) in no-till systems can be alleviated with the introduction of herbicides from Groups E, T and Q (eg Ultro, Luximax and Overwatch). The new chemistry used alone or in mixtures creates opportunities for targeting resistant weeds or managing resistance through alterntive use patterns.

The new Group E product Ultro (carbetamide) provides an alternative to trilflualin or propyzamide for pre-emergent grass weed control in pulses. Ultro will also reduce the heavy selection pressure on post emergent grass herbicides such as clethodim or clethodim + butroxydim (Factor) mixtures.

Crop rotation allows greater diversity with some of the new herbicide choices available. For example the new Group G product Reflex (fomesafen) has shown good control of broadleaf weeds such as sowthistle and prickly lettuce which are problematic in pulses. A heavy reliance on Imi chemistry in Clearfield® tolerant pulse crops has seen the development of resistance in brassica and thistle species. This new Group G product allows growers to relieve pressure on the Imi chemistry and strengthen the value of older herbicides such as simazine when used in a mixture.

Resistance stewardship – WeedSmart Big 6

As new chemistry becomes available it is crucial for all involved to protect the longevity of any new products and minimise the risk of resistance. The WeedSmart Big 6 brings together weed research data with grower experiences to create a set of practical guidelines focused on minimising the weed seedbank without compromising profit.

The WeedSmart Big 6:

1. rotate crops and pastures
2. double knock – to preserve glyphosate
3. test, mix and rotate herbicides
4. stop weed seed set
5. increase crop competition
6. adopt harvest weed seed control

Best practice agronomy is a key component of the Big 6 and pulls together all the aspects of profitable no-till cropping such as precision seeding, timely sowing, targeted nutrition, soil amelioration and crop competition so that crops have the edge over weeds. Tactics such as harvest weed seed control, cutting hay and diverse rotations are also essential to complement herbicide use including the mix and rotation of herbicides, double or triple knock and late season crop-topping.

Site specific applications such as shielded sprayers or optical spray technology are also effective at reducing herbicide inputs and introducing diverse chemistry. Application technology is now emerging as realistic option for controlling weeds and managing resistance. Optical spray technology is being developed for green on green scenarios where sensors detect weeds and activate the spraying of weeds only. Artificial intelligence and associated machine learning systems will reduce overall herbicide usage but also open up potential opportunities for high value chemistry or alternative site specific tools such as lasers.

Grower success in reducing weed seedbanks but staying profitable has been achieved through stacking Big 6 tactics over an extended period of time. For example, a diverse rotation with pulses, competitive barley and early sown hybrid canola combined with pre-emergent herbicides, opportunistic double knocks, croptopping and chaff decks has all the Big 6 tactics stacked together.

Harvest weed seed control – the mills are here

In 2020 the industry observed a surge in the adoption of weed seed impact mills for harvest weed seed control. Given a favourable season in the eastern states and moderate weed pressure, an increasing number of growers made the decision to invest between $60,000-$120,000 in one of the four impact mills available. These include the: Seed Terminator, iHSD – Harrington Seed Destructor, Redekop Seed Control Unit and Techfarm WeedHOG. With approximately 500 units now in use across Australia, growers are beginning to understand the strengths and weaknesses associated with the technology.

The objective of an impact mill is to grind, shear and crush the weed seeds contained in the chaff fraction of harvest residue. The objective is to get as many weed seeds into the header in order for

the mill to destroy the viability of seed and reduce the seedbank. On average, a harvester cutting low can capture 70% of the seeds prior to shedding or lodging and then destroy 98-99% of these weed seeds that enter the header. Overall the feedback has been positive especially those committed to making the system work over the long term, but a number of growers expressed concern with several issues. This included exorbitant running costs, mill wear, belt alignment and excessive heating, fuel use and loss of capacity. In a big season such as 2020 where crop yields were generally above average, the power requirements to harvest the crop are already significant, and a mill then adds more load on the machine. This in turn reduced operator output and subsequently increased costs which was frustrating during a wet harvest.

Not every harvest will be as slow and challenging as 2020 and all impact mill owners are encouraged to assess the true cost of the machine over a number of seasons. All systems involve compromise and the processing of weed seeds with an impact mill is no different. Working with the mill manufacturer and local dealer to review the strengths and weaknesses of the unit, and then following up in the paddock to see how well the machine worked is vital. Harvest weed seed control is a part of a long term commitment to controlling weeds. Like herbicides it requires ongoing learning and attention to detail to achieve success.

Summary

New chemistry is providing opportuntites for growers to manage resistant weeds using a broad range of herbicides. In order to protect these new products, the industry needs to continue working together to ensure farming practices include both chemical and cultural weed control options to keep seedbanks low and minimise the risk of resistance.

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