NORTHERN FOCUS
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# Wild oat herbicide resistance patterns

By Tony Cook[1], NSW DPI

It is clear that in recent years there has been increasing difficulty in achieving high levels of control of wild oats – both in broadleaf and cereal crops – and with a range of products including different mode of action herbicides. Although environmental conditions and spray application parameters always play an important role, herbicide resistance has been implicated in a lot of situations.

Part of the Northern Grower Alliance approach involves an extensive and broad network of experienced regional consultants and advisers. These advisers are critical in establishing the key research questions and project direction but also in providing an efficient extension pathway. But in this situation they also provided a mechanism to easily sample wild oat populations from a wide range of different situations.

## What was done?

A survey was conducted during October 2007 by 34 agronomists who collected seed samples from about 100 separate wild oat populations in an area from Westmar in southern Queensland to the Liverpool Plains and west to Walgett and Mungindi.

Samples were collected from two different scenarios:

- 'High risk' situations where herbicides had failed in 2007 or in previous years; and,
- 'Random level' situations where there was no history of any herbicide problem and generally no herbicide was actually applied in 2007.

Note: Although termed 'random level', these samples were likely to indicate a resistance level lower than randomly occurring as a true random pattern would include some 'high risk' samples.

All seed samples were sent to Plant Science Consulting for testing in which every sample was exposed to a common set of nine herbicides (Table 1).

## What was found?

The overall results are shown in Figure 1. As expected the results from the two scenarios differed widely in resistance frequency.

Where wild oat samples were collected from high risk situations the patterns of resistance were alarming:

- 70–80 per cent showed some level of resistance to either Wildcat or Topik;
- 25–30 per cent had some level of resistance to Verdict, Axial or Mataven;
- 16 per cent had some level of resistance to Atlantis; and,
- 7 per cent had some level of resistance to Select.

Only the pre emergent treatment of Triflur X and Avadex Xtra provided complete control of all populations. But it is important to note the experimental method for pre emergent activity involved seeds being directly sprayed with the herbicide mixture and then covered with one cm of fresh soil. This is to simulate an 'incorporation by sowing' approach where seeds are surface germinating. Complete control is very

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## Consultants' Corner

Consultants' Corner is an initiative by *Australian Grain* highlighting current GRDC-funded research with a particular focus on the commercial implications of adopting cutting-edge research.

◁i...CONSULTANTS' CORNER

rarely achieved with this approach under real life conditions. Under these conditions, there will always be variability in weed 'sowing depth' as well as 'striping' in control patterns due to planter soil disturbance and 80–90 per cent levels of control are more common.

Where wild oat samples were collected from random level situations the resistance frequencies were much lower but still concerning:

- 10–20 per cent of populations showed some level of resistance to either Wildcat or Topik; and,
- Only one population showed resistance to Mataven.

No resistance was detected to any other herbicide evaluated.

**TABLE 1: Every sample was exposed to a common set of nine herbicides**

| Product | Herbicide group | Sub group | Weed growth stage at application |
|---|---|---|---|
| Triflur X + Avadex Xtra | D J | | Pre emergent |
| Wildcat | A | fop | Three-leaf |
| Topik | | | |
| Verdict | | | |
| Axial | | den | |
| Select | | dim | |
| Atlantis | B | | |
| Mataven | Z | | Stem elongation |

**FIGURE 1: Overall resistance patterns**

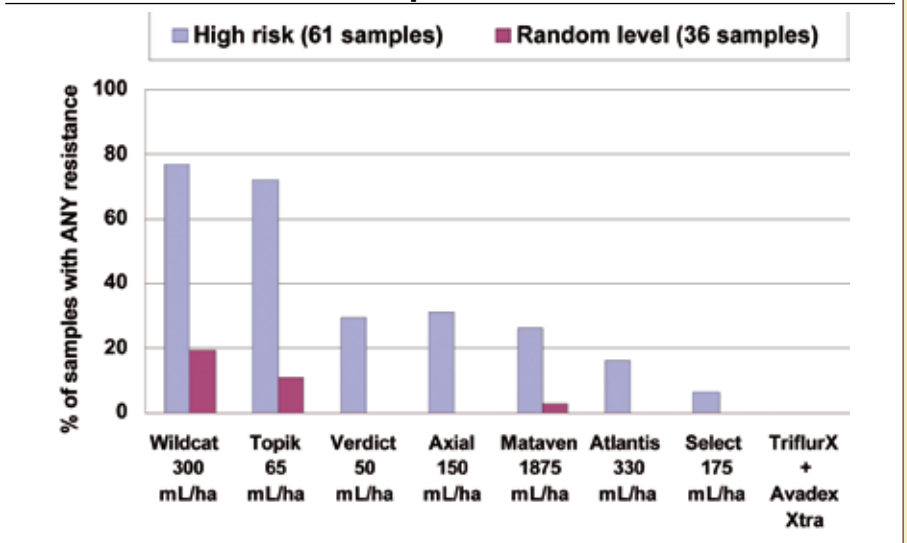
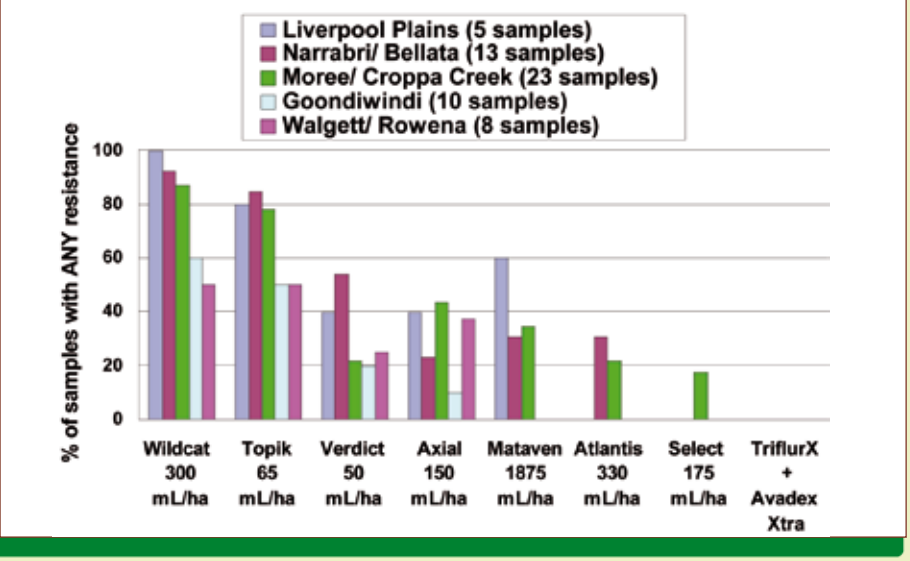



**FIGURE 2: Resistance patterns by 'area' sampled (high risk samples)**




## Did the patterns vary by sampled area?

When the survey was conducted it was expected that lower resistance frequencies may have been found in western areas where use of group A herbicides had been less frequent or in areas such as the Liverpool Plains where summer cropping has predominated in recent years with much lower selection pressure on wild oat selective sprays. But the results of the high risk samples showed similar trends across the five broad 'areas' sampled particularly for the group A products: Wildcat, Topik, Verdict and Axial.

## Application timing can be critical

Wildcat, Topik and Verdict are all group A herbicides and members of the 'fop' sub group. Figure 1 highlights a large difference in result between Wildcat and Topik compared to Verdict.

These results suggest that the resistance mechanism is not primarily 'target site' – where all fops would be expected to show similar resistance patterns but 'metabolic resistance' – where the weed has a mechanism to metabolically degrade the herbicide.

In these situations it was expected that levels of control may be improved at early weed growth stages. Additional testing of seed samples during August 2008 highlighted this relationship when Topik was used.

Clearly when dealing with Group A resistant wild oat populations the most sensible approach is to avoid the use of Group A herbicides completely. But if growers are forced to use these products then it will be important to 'go early and go hard'.

## TO SUM UP

The past regional survey in the north identified wild oat group A herbicide resistance in 10 per cent of populations. This survey, five years later, indicates the level has increased to at least 10–20 per cent of populations but most likely much higher.

Clearly herbicide resistance in wild oats

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is a widespread issue in the north. Changing management strategies, including the use of summer crop rotations, will be an important component of any long term approach.

Seed bank management will also be a key component to limit the magnitude of the problem in individual paddocks. But it is important to remember that no single product or single strategy will provide the long term solution. We need to incorporate a mix of strategies with the ultimate objective being to diminish wild oat seed banks.

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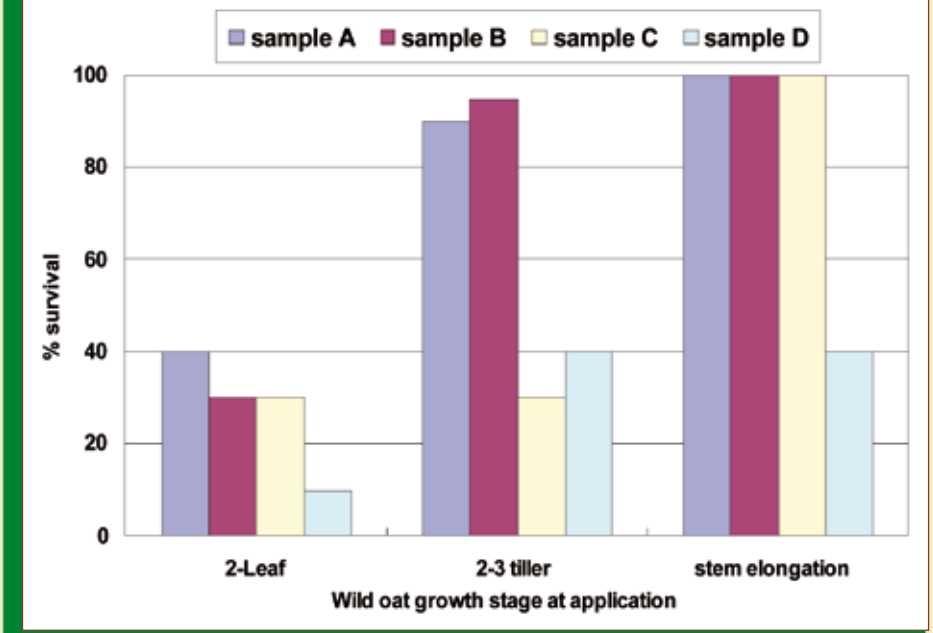
**FIGURE 3: Impact of application timing on wild oat control**




## RESEARCH VIEW – BREAKING THE MULTIPLE RESISTANCE CYCLE

There are many infestations of multiple resistant wild oats in the northern grain region, particularly in northern NSW. But as recently as 15 years ago, this phenomenon was relatively rare.

Why the sudden 'blow-out' in these hard to control wild oat populations? And can we break the cycle of these multiple resistant populations?

Before we can answer these questions we need to understand the life cycle of wild oats and past farming practices that led to herbicide resistance.

### Life cycle of wild oats and the evolution of herbicide resistance

Wild oats persist in cropping systems due to their seed production. Although the relatively short-lived wild oat seed bank has a minor role, the survival of a small proportion will produce enough seed to replenish the seed bank, thus guaranteeing the persistence of wild oats.

A good way of thinking about this is to start with a seed bank of 10 seeds per square metre. Assuming that 90 per cent of these seeds germinate (nine plants), that would leave one seed per square metre in the soil. Of the nine plants that emerge, post-emergent sprays would normally kill eight, resulting in one surviving plant. This plant could have survived due to several reasons; shading, wheel tracks, poor application or possibly herbicide resistance. Seed production from this survivor needs to be at least nine seeds to top up the seed bank to the original level. If herbicide resistance is the cause of survival, the evolution of herbicide

**TABLE 1: Effect of using two effective treatments on Group A resistant wild oats**

| Treatment(s) | Rate of product/ha | Herbicide group(s) | Wild oat plants per m² | Wild oat seeds per m² |
|---|---|---|---|---|
| Topik (post-em)# | 65mL | A | 5.0 | 180.9 |
| Wildcat (post-em)* | 300mL | A | 2.4 | 123.3 |
| Achieve (post-em)* | 380g | A | 1.0 | 43.8 |
| Control | — | — | 2.1 | 90.7 |
| Avadex Xtra (pre-em) | 1.6L | J | 0.3 | 9.4 |
| Atlantis (post-em) * | 330mL | B | 0.1 | 4.2 |
| Hussar (post-em)* | 200g | B | 0.2 | 2.3 |
| Avadex Xtra (pre-em) + Mataven 90 (SST)# | 1.6L + 1.875L | J + K | 0.0 | 0.0 |
| Mataven 90 (SST)# | 1.875L | Z | 0.1 | 0.4 |
| Atlantis (post-em) *+ Mataven 90 (SST)# | 330mL + 1.875L | B + Z | 0.0 | 0.0 |
| Avadex Xtra (pre-em) + Atlantis (post-em)* | 1.6L + 330mL | J + B | 0.0 | 0.0 |
| Avadex Xtra (pre-em) + Hussar (post-em)* | 1.6L + 200g | J + B | 0.1 | 0.3 |
| Hussar (post-em)* + Mataven 90 (SST)# | 200g + 1.875L | B + Z | 0.0 | 0.0 |
| Avadex Xtra + Trifluralin 480 (pre-em) + Atlantis (post-em)* | 1.6L + 1.5L + 330mL | J + D + B | 0.1 | 0.1 |
| Crusader (post-em)* | 500mL | B | 0.0 | 0.0 |

* = non-ionic wetter at 0.2 per cent v/v (100mL/100L water). # = Uptake at 0.5 per cent v/v (500mL/100L water).

resistance commences. The likely seed production from resistant individuals would be at least 100 to 200 seeds per plant. The final result is a 'blow-out' in resistance.

The repeated practice of relying upon a single application of post-emergence herbicides, without controlling these survivors has meant that small patches dominate paddocks and farms. Those farms that rotate from winter to summer crops have fared well in general, as this breaks the cycle of resistance. But there are some regions that cannot grow summer crops due to restrictive rainfall in warmer months.

Scientific evidence has shown that two successive winter fallows are required to reduce seed banks by 99 per cent. Therefore, summer cropping or long fallowing can be seen as a high priority strategy.

### The history of multiple resistance in wild oats

As one herbicide group fails, farmers change their herbicide to an alternative mode of action (MOA) group. A simple change from MOA group 'fop' to 'dim' (both group A herbicides) was usually enough to combat this problem, albeit temporarily. But all it takes is one individual resistant to the dim chemistry and the start of the multiple resistance cycle begins. The abuse of dim herbicides with no strategy to control survivors was a recipe for entrenched multiple resistance. This is one example of the development of multiple resistance in wild oats.

Another case of multiple resistance can arise from cross-resistance. A common example is fop resistant populations developing resistance to Mataven (Group Z) without any history of Mataven use. This is caused by the mutation on the enzyme that affects fop and Group Z herbicides simultaneously.

So have we learnt from these past errors in management when the new generation of Group B wild oat herbicides were released in the early part of this decade? The answer is no. Grain growers have used these new Group B herbicides like the ones that failed before. It is no wonder that there are now populations that are resistant to all in-crop wheat post-emergence herbicides.

It is time to make some radical changes to ensure that we preserve the remaining effective herbicides.

## WHAT OPTIONS ARE AVAILABLE TO USE?

### Populations susceptible to at least one post-emergence herbicide

The first option to consider is pre-emergence herbicides. Previously, the use of trifluralin (Group D) or Avadex Xtra (Group J) was not common. Their limited use implies the chances of resistant individuals in populations are extremely low. This can be seen as an opportunity as these herbicides have a role to play in reducing wild oat numbers as the crop emerges. But if all post-emergence herbicides are no longer effective the continual use of pre-emergence herbicides is not viable for two reasons:

- Pre-emergence herbicides usually result in 70 to 90 per cent control and small densities can rapidly thicken up, as survivors from these treatments tend to be large and produce many seeds (up to 500 seeds per plant); and,
- The likelihood of developing resistance.

To maximise the control achieved by pre-emergence herbicides, a tank mix of trifluralin and Avadex Xtra can be used. Apart from belonging to different herbicide groups, the herbicides complement each other by acting on different parts of the weed. Avadex Xtra affects new shoots that are pushing through the soil but may leave many soil surface germinating wild oat plants. But trifluralin kills seedling wild oats by preventing root development. Therefore, surface germinating oats have less chance of surviving if their roots are prevented from growing.

Successful use of pre-emergence herbicides is only as good as follow-up control measures. Provided that there are some useful in-crop post-emergence treatments left, there is some hope to get control of wild oats.

This was best demonstrated by NSW DPI research undertaken in 2007. A Group A (fop and dim) resistant population from North Star was sprayed with combinations of pre- and post-emergence herbicides. The results (Table 1) show that using a combination of pre- and post-emergence herbicides could severely reduce wild oat seed production. Without this seed production, wild oat populations cannot persist.

Figures in Table 1 highlight the poor level of control from Group A herbicides. They also show that solely relying upon herbicides such as trifluralin and Avadex Xtra will result in sufficient seed production to perpetuate wild oat seed banks.

The tactic of using a pre- and post-emergence herbicide is sound provided that wild oats are susceptible to post-emergence herbicides. More radical tactics are required if wild oats exhibit resistance to most in-crop post-emergence herbicides.

### Know what you are dealing with – test for what does and doesn't work

To ensure effective weed control the farmer must know which herbicides still kill the population. This means that some form of herbicide resistance testing must be conducted. Farmers should be planning for next season already.

- Test for all herbicide modes-of action. This will be cheap insurance against herbicide failure next season; and,
- Pick your high risk paddocks first. These are the ones that have received more than six to eight Group A herbicide applications, particularly where weed numbers have been high.

There are two main options.

**SEED TESTING:** Seed can be collected at the end of the season and sent to the testing service who will give a report on the level of resistance. Due to the nature of the test, results won't be available until March-April next year. (See contact details below.)

**THE QUICK-TEST:** This involves digging up live plants and sending them to the testing service. The weeds are then trimmed, potted, regrown and sprayed. Turn around time is four to six weeks. If done early in the season results can be returned to make accurate management decisions on the current crop. But, samples can be submitted now, for planning next year's program. (See contact details below.)

If there is a problem in this year's crop, a field trial can be conducted comparing higher rates of a range of herbicide MOA's, but this form of testing requires professional interpretation due to variations in weather, weed size, soils and application.

Field trials can give useful information for planning, but not action this season, unless you are willing to spray out patches of crop and resistant weeds before seed set with glyphosate.

**Seed testing:**
**John Broster, Charles Sturt University, Wagga Wagga NSW**
**Phone: 02 6933 4001, Fax: 02 6933 2924**
**Email: jbroster@csu.edu.au**
**Peter Boutsalis, Plant Science Consulting, Prospect SA**
**Phone: 0400 664 460, Fax: (08) 8342 4606**
**Email: info@plantscienceconsulting.com**

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