the northern
HERBICIDE RESISTANCE Reporter

MARCH 2003

A Newsletter keeping you up to date with research and development in herbicide resistance in the Northern Region

Herbicide mode of action awareness

Australia leads the world in herbicide resistance prevention and management. Since 1997, all herbicide labels in Australia have displayed a letter from A to N denoting the mode of action (MOA) of the herbicides active ingredient. The MOA groups are assigned according to the plant processes that the herbicide interferes with. The MOA grouping was introduced as a key component of the strategy to prevent or delay the development of herbicide resistant weeds.

The recent postal survey to agronomists asked for an indication of their client awareness of these MOA groups. Knowledge of MOA groups is vital if rotating herbicides is to prevent development of resistant weeds. Most growers across the northern grain region generally have some awareness of MOA groups (32%) while fewer (29%) have a moderate awareness and only 17% have a good awareness (Table 1). The awareness of growers to MOA groups is generally lower in CQ and better in NSW. This may be because there are fewer herbicide resistance issues currently facing CQ growers.

Table 1. The awareness of growers in the northern grain region to herbicide mode of action groups.

Region	Statistical Region	Level of Awareness (%)			
		Good	Moderate	Some	None
CQ	Mackay	5	10	20	65
	Fitzroy	5	12	45	38
SQ	Wide-Bay Burnett	10	20	50	20
	Darling Downs	18	35	28	19
	South West Queensland	15	40	35	10
Northern NSW	North-Central Plains	35	36	24	5
	Northern Slopes	16	31	37	16
Central NSW	Macquarie Barwon	22	43	26	9
	Central Macquarie	22	38	24	16
Average		**17**	**29**	**32**	**22**

The project aims to increase the awareness of growers to MOA groups and how rotating these groups can help in preventing herbicide resistance.

Michael Widderick

In this issue ...

Cooperative Research Centre for Australian Weed Management

The Cooperative Research Centre for Australian Weed Management (Weeds CRC) is a Commonwealth-funded initiative that enables weed researchers across Australia to collaborate on research. The national focus of the Weeds CRC enables information to be shared over Australia and ultimately improves the weed research being carried out in this country.

The Weeds CRC addresses environmental damage, loss of agricultural production and health issues for both humans and animals resulting from weeds. There are five programs in the Weeds CRC to address these issues: weed incursion and risk management, sustainable cropping

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systems, education, landscape management and community empowerment. Research on herbicide resistance in Australia comes under the banner of sustainable cropping systems.

Throughout Australia there are similar research projects underway (including the ones highlighted in this newsletter) to look at IWM strategies based upon reducing the risk of herbicide resistance. The Weeds CRC helps to bring these projects together and will facilitate in the production of an IWM manual with principles suitable for all Australian environments.

Other herbicide resistance projects in the Weeds CRC are investigating the mechanism of glyphosate resistance and modelling the impact of IWM strategies used to minimise herbicide resistance. For further information on the Weeds CRC and herbicide resistance projects go to the Weeds CRC website www.weeds.crc.org.au

Michael Widderick

Editorial

The herbicide resistance team in the north has been very busy since we last made contact as this issue highlights. A major achievement has been conducting workshops throughout the region. These were held at Dalby, Goondiwindi, Roma, Miles, Edgeroi, Croppa Creek, Coonamble, Spring Ridge, Emerald and Biloela. The workshops were very successful, enabling us to validate the survey and gain insight into on-farm issues relating to herbicide resistance. We are grateful to the people who attended these workshops and intend to have continued contact with these groups.

The team met in Tamworth in November and firmed our operational plan for the next six months. Our focus will be devising best weed management practices for high risk weeds and evaluating these on-farm. The team will be meeting again in May to further progress the project.

The most visible part of our work will be the on-farm trials. NSW has commenced their trials and unfortunately in Queensland putting down trials has been delayed due to adverse weather conditions. However, as soon as conditions improve, the trials will get underway.

We would appreciate any comments or newsworthy articles in relation to herbicide resistance. Our contact details are provided on the back page, so please keep in touch.

Kathryn Galea , Michael Widderick

Herbicide resistance is a risky numbers game

Evolution of herbicide resistance in weeds is due to the intense selection pressure exerted by herbicides. Major factors influencing the appearance of herbicide resistance are:

- the intensity of the selection pressure,
- the initial frequency of herbicide resistant genes within the population, and
- the biology of the weed species.

The intensity of the selection pressure is a combination of the efficacy of the herbicide and the number of times that herbicide is applied. The greater the efficacy of the herbicide, the greater the selection pressure for resistance. Repeated and exclusive use of a herbicide will therefore increase the likelihood that the population will become resistant to that herbicide.

The greater the frequency of resistant genes within a population, the quicker the likelihood of resistance developing. The frequency of resistant genes is an important but largely unknown quantity. Typically it is quoted that there is one resistant individual in every one million plants, however, this is likely to vary for different weed species and different herbicides.

The biology of a weed species directly influences the likelihood and speed at which herbicide resistance develops. A weed with a persistent seed bank is able to delay the onset of herbicide resistance by diluting the number of resistant genes. In addition, herbicide resistance is more likely to appear in paddocks with a large number of plants, as the likelihood of a resistant plant within the paddock increases.

The important concepts of herbicide resistance, as outlined above, drove the risk assessment performed on data from the herbicide resistance survey to determine weeds most at risk of developing herbicide resistance in the northern grain region. The factors used in the initial risk assessment are presented in table 1 and the relative importance of these factors in determining risk is shown by the number of ticks. Factors with higher importance (more ticks) were given a greater weighting in the calculation of the risk assessment.

Table 1. Factors used in calculating the herbicide resistance risk of weeds in the northern grain region.

Risk Factor	Importance/Weighting
Herbicide use frequency	✓✓✓✓
Herbicide efficacy	✓✓✓
Dense weed infestations	✓✓
Risk of herbicide group *(High, medium, low)*	✓✓
Herbicide applied alone	✓✓
No follow-up herbicide	✓✓
Zero tillage	✓✓
Lack of other non-chemical options	✓

The risk for herbicide resistance has been further refined based on crop rotation and herbicide use patterns in different components of the rotation. This information was supplied by agronomists and growers who attended recent herbicide resistance workshops. Further detail on the workshops and revised risk assessment is provided in the article 'Ground truthing survey results'.

Michael Widderick

Ground truthing survey results

The important information from the postal survey was validated by consulting with a range of growers and agronomists at a series of herbicide resistance workshops. These workshops were at 10 locations (Spring Ridge, Coonamble, Edgeroi, Croppa Creek, Goondiwindi, Roma, Miles, Dalby, Emerald and Biloela) with 225 growers and agronomists attending.

At each workshop, a presentation was given on the herbicide resistance status for that region, plus a comprehensive summary of the survey results. This lead to useful discussion and questions that helped to verify, clarify and update the information gained from the survey. At the NSW workshops, presentations on weed seed bank management and the economics of herbicide resistance were also given.

Workshop participants then identified the most common crop rotations and herbicide use patterns for their region. This process generated a lot of discussion in regard to likely herbicide resistance scenarios. Participants were also asked to indicate what research, development and extension work that they felt was required to help them avoid development of herbicide resistance in their systems.

This important information was then used to revise our list of weeds at risk of developing herbicide resistance for each region and has helped us to define which weeds we will target in our on-farm experiments. The newly revised list of target weeds and MOA groups is presented in table 1 and the rotations in which these weeds are to be targeted are presented in table 2.

In addition to the target weeds in table 1, other common weeds including bladder ketmia, fleabane and saltbush (SQ), paradoxa grass and wire weed (NSW), parthenium and african turnip weed (CQ) will be monitored to a lesser degree in this project. Some of these weeds be looked at more closely in another current project looking at BWM in rotations with dry land cotton. Any relevant information on these weeds from the cotton project will be presented in later editions of this newsletter.

Table 1. Weeds and MOA groups to be targeted in on-farm experiments.

SQ		CQ		NSW	
Common sowthistle	B,M	*Common sowthistle*	B,I,M	*Common sowthistle*	B,I,M
Turnip weed	B	*Liverseed grass*	M	*Wild oats*	A,M
Barnyard grass	M	*Barnyard grass*	C	*Black bindweed*	B,I,M
Liverseed grass	M	*Sweet summer grass*	M	*Rye grass*	M
Wild oats	M,A	*Black pigweed*	C	*Liverseed grass*	K,M
Black bindweed	B			*Turnip weed*	B

Michael Widderick (above) and Andrew Storrie (left) present information at the recent herbicide resisitance workshops.

All involved in the workshops would agree that the transfer of information was beneficial, and the project team would like to thank all those who willingly helped to organise and participated in the workshops.

Michael Widderick, Vikki Osten, Paul Moylan

Table 2. Cropping rotations to be targeted in on-farm experiments.

Region	Rotation
SQ	Wheat - Wheat - Chickpea - Sorghum
	Wheat - Chickpea - Wheat - Sorghum
	Wheat - Wheat - Chickpea
NSW	Sorghum - Long Fallow - Wheat - Long Fallow
	Wheat - Wheat - Barley - Short Fallow
	Opportunity cropping system based around availability of stored soil moisture.
CQ	Opportunity cropping system based around availability of stored soil moisture, used for approximately 95% of cropping in CQ.

Best weed management strategies

For each target weed, alternative weed management strategies are being developed for testing on-farm. These strategies aim to reduce the risk of herbicide resistance while also better managing the weeds in the long-term. Four broad strategies will be compared agronomically and economically:

1. **Mimic of the normal district practice.**
2. **Best herbicide technology in combination with rotating herbicide MOA groups.**
3. **Best herbicide technology in combination with rotating herbicide MOA groups and a non-chemical management option.**
4. **Same as strategy 3 plus managing weeds that escape initial management efforts by using either chemical or non-chemical options.**

The management strategies will be devised based upon a knowledge of the ecology and biology of each weed species. Further detail of the treatments to be imposed will be given in future newsletter issues.

Michael Widderick

What are we doing on-farm?

On-farm experiments have commenced to test strategies that minimise the risk of herbicide resistance for the target weeds identified through the study and to improve the management of these weeds by using chemical and non-chemical options. These on-farm experiments are in 2 forms. Short-term experiments will compare management options more closely in different phases of the rotation or in managing a specific weed species, and long-term experiments will trial different weed management options within the normal district crop rotation.

The NSW sites are at Spring Ridge, Coonamble and Edgeroi. Spring Ridge has three experiments, one focusing on the sorghum – long fallow – wheat rotation, another on an opportunity cropping strategy and the third on the wheat – long fallow – sorghum phase of the cropping rotation. Coonamble has 2 experiments that focus on a winter cropping rotation with wheat and chickpea, and Edgeroi has 2 experiments with a sorghum and wheat. Further details on these experiments will be provided in future issues of the newsletter.

NSW long-term on-farm trial being planted.

The SQ on-farm experiments are about to commence at sites near Goondiwindi, Roma and Miles. A short-term experiment on the best herbicide technology for managing common sowthistle in summer fallow will begin once a suitable experimental site is found.

The CQ direction for long-term on-farm experimental work is still to be decided, to take into account the conflict between applying the principles of integrated weed management and the current push for wide-row cropping systems. However, short-term experiments are planned to investigate glyphosate alternatives on fallow weeds.

Paul Moylan, Vikki Osten, Michael Widderick

A new molecular tool to detect triazine herbicide resistant weeds

Resistance is normally first suspected only after farmers observe a reduction in efficacy or failure by herbicides. Unfortunately, by this time the frequency of resistant individuals has reached a high level making management difficult. The "early" detection of herbicide resistant weeds would enable farmers to implement control strategies while the size of the resistant population is small and before the problem gets out of hand.

Our research is currently focused on group C herbicides, including the triazines. Most of the resistance to triazines has resulted from gene mutations. Recently, our lab developed a molecular tool that can distinguish between susceptible and triazine resistant weeds. We conducted tests on triazine-resistant canola, and three weed biotypes which were Common groundsel, Barnyard grass and Blackberry nightshade. The test was able to discriminate between triazine-resistant and susceptible plants with 100% accuracy. The advantage of our newly developed test is that it is reliable, simple, fast, and accurate. Within one day we can test large numbers of samples from a single paddock. This enables the early detection of resistant biotypes when they are present at only low frequencies. Moreover, with our molecular tool, weeds at the cotyledon stage (just after they germinate) can be sampled and results could be available to farmers within two days. This will help farmers decide if it is feasible to use triazines or not. This will not only reduce the amount of herbicide released into the environment but will save the farmers' money and time.

It is expected that this method will be developed into a useful tool to monitor the frequency of resistant individuals at the farm and regional level. We are also developing tools to detect resistance to other herbicide *mode of action* groups. Hopefully in the near future we will deliver a testing service to grain growers.

Wenjie Liu, Dion Harrison, Steve Adkins, Richard Williams

Up to date information on herbicide resistant winter weeds

Prior to 1993 there were no reports of herbicide resistant weeds in the Northern grain region. There are now in excess of 83 grass and broadleaf weed populations where resistance has been confirmed. Group A resistance in wild oats is the most prevalent with over 40 confirmed cases. This is followed by 32 cases of various broadleaf weeds that are resistant to Group B herbicides (common sowthistle 19, Indian hedge mustard 9, African turnip weed 2 and climbing buckwheat 2). Seven populations of liverseed grass are resistant to Group C herbicides. This pattern is somewhat different to the occurrence of herbicide resistance in the rest of the world where Groups A, B and C, account for 13%, 22% and 37% of cases, respectively.

Project UQ 138, funded by GRDC, began in 2001 and is attempting to further delineate the current extent of herbicide resistance in the NR using random surveys. The first sampling was from 121 in-crop paddocks during October – November 2001. Ninety eight of these paddocks were dominated by wild oats and the remainder were dominated by broadleaf weeds such as climbing buckwheat, common sowthistle, African turnip weed and turnip weed.

The wild oats were tested for Group A resistance with the herbicide "Wildcat®" (containing 100g/L fenoxaprop-P-ethyl) using a test called the "Rothamsted Rapid Resistance Test". This test, often simply abbreviated to RRRT, was developed by Dr. Stephen Moss at the Rothamsted research station in the UK, and tests for resistance by germinating weed seeds in Petri dishes containing dilute solutions of herbicide. Known "susceptible" and "resistant" populations are included in the test as reference samples. The results showed that two wild oat populations, one each from the Warren and Gilgandra shires were strongly resistant. A further eight populations (from the Coonamble, Gunnedah, Milmerran, Narromine, Pittsworth, Tara, Waggamba, and Walgett shires) showed some degree of insensitivity to Group A. None of the broadleaf weeds that were collected showed any level of resistance to Group B herbicides which were screened using standard pot spraying tests.

A service currently offered by project UQ138 to farmers and advisors in the NR is the ***Herbicide Resistance Testing Service (HeRTS)***. If farmers find that their herbicides seem to be having less effect on target weeds then they can send some seed from surviving plants to HeRTS for testing. Contact Chris O'Donnell (07) 5460-1345 and ask for a consignment pack which includes a pre-addressed POSTpak, a herbicide history form and information on how to collect seed. To-date, approximately 2/3rds of all samples submitted to HeRTS have shown strong levels of resistance.

Chris O'Donnell

Preliminary results for Spring Ridge sorghum experiment

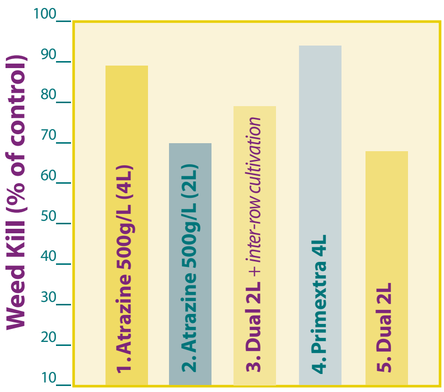
As mentioned in the article 'What are we doing on-farm?', an on-farm experiment at Spring Ridge is underway looking at herbicide options in a sorghum – long fallow rotation. Table 1 shows the herbicide treatments that have been imposed.

Table 1. Herbicide treatments imposed at Spring Ridge in-crop (sorghum).

Treatment	Rates (L/ha)	Timing of Application	MOA Group
1. Atrazine 500g/L + Atrazine 500g/L + Starane 200g/L (fluroxypyr)	4 (pre) 5 (post) + 0.5	Pre & Post	C + I
2. Atrazine 500g/L + Starane 200g/L	2 + 0.5	Post	C
3. Dual (metolachlor) + inter-row cultivation	2	Pre	K
4. Primextra (metolachlor + atrazine)	4	Pre	K + C
5. Dual	2	Pre	K
6. Control (no post plant treatment)			

Plant counts were taken to ascertain the change in weed population from mid December 2002 until late January after the first treatments had been applied. Figure 1 shows the efficacy of these treatments in controlling weeds such as barnyard and liverseed grass, bladder ketmia, yellow vine, black bindweed, dead nettle, castor oil and noogoora burr.

Figure 1. Weed control (%) in sorghum with different herbicide treatments.



From this preliminary data, one can suggest a pre-planting application of Primextra® at 4L/ha and/or Atrazine at 4L/ha are effective in managing the weed population until the crop can become more competitive. This is despite below average rainfall conditions. Further results from this and other experiments will be in future issues of this newsletter.

Paul Moylan

More on the 2002 wheat competition study in CQ

In the September edition, we discussed the impact of wheat row spacing, crop population and weed management regime on early wheat growth (biomass) in a replicated small plot trial undertaken in Emerald. Since then weed and crop yield data have become available. The following is a summary of how row spacing and plant population made a large difference to the level of weed control and crop productivity.

Chickpea, the simulated weed for this study, was sown 3 weeks before the wheat crop. The wheat was sown at 4 seeding rates to produce populations of 500 000, 750 000, 1 000 000, and 1 250 000 plants/ha in 4 row spacings of 25, 30, 37.5 and 50cm. Half of the plots were sprayed with metsulfuron-methyl + MCPA, which gave very good control of the simulated weed.

All the main treatment factors (row spacing, crop population, weed control) had a significant and major impact on wheat yield. As well, there was a significant 3-way interaction (row spacing x crop population x weed control regime), and these wheat yield data for the 3-way interaction are presented (Table 1).

Spraying the weeds increased wheat yield by an average from 1.31 to 2.87 t/ha. Increasing the row spacing of the sprayed plots from 25 to 50cm decreased wheat yield from 3.08 to 2.61 t/ha. The highest yields, which were greater than 3 t/ha, were achieved from the sprayed wheat in 25 cm rows with populations between 0.75 and 1.0 million plants per ha.

Table 1. Impact of row spacing, crop population and weed control on wheat yield.

Row Spacing (cm)	Crop Population (plants/ha)	Wheat yield(t/ha)	
		Sprayed	*Unsprayed*
25	**500 000**	**2.96**	**1.19**
	750 000	**3.13**	**1.34**
	1 000 000	**3.07**	**1.60**
	1 250 000	**3.14**	**1.83**
30	500 000	2.75	1.17
	750 000	3.04	1.48
	1 000 000	2.99	1.70
	1 250 000	2.78	1.90
37.5	**500 000**	**2.80**	**0.97**
	750 000	**2.96**	**1.15**
	1 000 000	**2.89**	**1.63**
	1 250 000	**2.92**	**1.55**
50	500 000	2.59	0.64
	750 000	2.60	0.94
	1 000 000	2.66	1.02
	1 250 000	2.57	0.82
LSD (5%)			**0.29**

Similarly, all the main treatment factors had a significant impact on weed control (Table 2). In addition, there were significant 2-way interactions for row spacing x weed control regime, and for crop population x weed control regime.

Row spacing and crop population had no affect on the level of weed control, as the herbicide treatment was very effective. However for the unsprayed plots, weed growth was substantially greater in the wider rows, particularly for the 50 cm row spacing. As well, weed growth was greater in wheat populations less than 1 million per ha.

Table 2. Impact of row spacing, crop population and weed control on weed growth.

Treatment	Weed yield at harvest (t/ha)	
	Sprayed	Unsprayed
Row spacing (cm)		
25	0	1.01
30	0	0.92
37.5	0	1.06
50	0	1.44
LSD (5%)	**0.19**	
Crop Population (plants/m²)		
500 000	0	1.39
750 000	0	1.20
1 000 000	0	0.98
1 250 000	0	0.87
LSD (5%)	**0.11**	

In summary, wheat yield was highest and weed control was greatest in narrow rows with high crop populations. When herbicides are not fully effective, this strategy of improved crop competition will also provide extra assistance to weed management by reducing the amount of seed set on surviving weeds. Growing wheat in wide rows (50 cm) affords neither of these benefits.

Vikki Osten, Megan McCosker and Glen Wright

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Importance of narrow row spacing for good weed control and high yields

Increasing the row spacing of wheat and barley can adversely affect weed control and crop yields. When growing winter cereals in wider rows, reliance on herbicides is greater due to less crop competition, and often more weeds survive the herbicide application. This can increase the risk for herbicide resistance and more problems in the future. More import-antly, it can reduce productivity.

The project team inspect a crop competition experiment at Tamworth.

The impact of increasing row spacing up to 35cm was found to be relatively small, but was much greater when increased further to 50cm. DPI staff (John Marley, Vikki Osten, Geoff Robinson, Steve Walker, Michael Widderick) researched the impact of different row spacing in 11 trials at sites from Goondiwindi to Emerald.

Weed biomass increased by an average of 8% when row spacing was increased to 35cm, but increased by 2-19 fold when row spacing was increased to 50cm (Table 1). Wheat yield were reduced by 9 to 20% in sprayed and weed-free plots, and from 5 to 42% in weedy plots, when grown in 50cm rows (Table 2).

Table 1. Impact of row spacing on weed control.

Row spacing (cm)	Site	Weed	Impact
17.5⇨35	1-5	Turnip weed (unsprayed)	Biomass increased by mean of 8%
25⇨50	**6**	**Sowthistle (unsprayed)**	**Biomass increased by 2 fold**
25⇨50	7	Sowthistle (unsprayed)	Biomass increased by 19 fold
25 ⇨50	**8**	**Sowthistle (sprayed)**	**Number of survivors increased by 3 fold**
25⇨50	9	Chickpea (sprayed)	Biomass of survivors increased by 70%
25⇨50	**10**	**Too few due to dry seasons**	
25⇨50	11	Too few due to dry seasons	

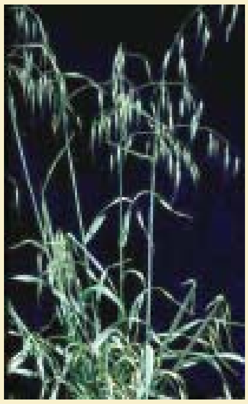
Table 2. Impact of row spacing on wheat yield.

Row spacing (cm)	Site	Weed	Impact
17.5⇨35	1 - 5	Turnip weed (unsprayed) Turnip weed (sprayed)	2.52 ⇨ 2.42 (mean of 4% loss) 3.23 ⇨ 3.09 (mean of 4% loss)
25⇨50	**6**	**Sowthistle (unsprayed) Sowthistle (sprayed)**	**1.32 ⇨ 1.10 (17% loss) 1.33 ⇨ 1.21 (9% loss)**
25⇨50	7	Sowthistle (unsprayed)	2.47 ⇨ 2.35 (5% loss)
25⇨50	**8**	**Sowthistle (sprayed)**	**1.95 ⇨ 1.39 (29% loss)**
25⇨50	9	Chickpea (sprayed) and Chickpea (unsprayed)	3.08 ⇨ 2.61 (15% loss) 1.49 ⇨ 0.86 (42% loss)
25⇨50	**10**	**Weed-free**	**1.82 ⇨ 1.45 (20% loss)**
25⇨50	11	Weed-free	1.24 ⇨1.01 (19% loss)

Steve Walker

Wild oats biology

Wild oats was identified through the recent survey as the most common weed in central NSW, the third most common weed in northern NSW and the fourth most common weed in southern Queensland. In addition, there are several wild oat populations in the northern grain region with resistance to group A herbicides and the weed is perceived as being at high risk to group M herbicides.



There are three species of wild oats common in Australia with *Avena fatua* most common in southern Australia and *A. ludoviciana* more prevalent in northern NSW and Queensland. The third species, *A. barabata*, occurs mainly on roadsides.

Wild oats is competitive in crop and often grows in patches or clumps. Mature plants can grow up to 120 cm tall and can be found over a wide range of soil textures and a pH range from 4.5 to 9. Young wild oat plants have distinct blue-green colour leaves that are twisted in an anti-clockwise direction, opposite to the leaves of wheat and barley.

The seeds of wild oats are usually dark brown in colour and are often hairy on the lower half. Temperature and moisture are important factors in controlling the germination of wild oat seeds. Germination is greatest between 10 and 26.5°C allowing seeds to germinate during autumn and winter. Buried seeds remain dormant in the soil and are able to germinate once returned close to the soil surface. However, the seeds of wild oats are relatively short-lived with half the seeds disappearing every six months. Wild oats produce a maximum number of 225 seeds per plant which are readily spread as contaminants of fodder, grain and machinery.

Evidence strongly suggests that wild oats rapidly declines when replenishment of the soil seed bank is minimised and that the production of new seeds is the main mechanism for persistence of this weed.

Michael Widderick

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