

Samples Received

The testing service screened 301 samples in 2021. This was larger than the last three years but less than five of the six years before then (2012-2017).

More wild samples than in any previous year were received this year. In fact, it was not until the final ryegrass samples were received in late July that more ryegrass samples than wild oats had been received (Table 1), this was due to Corteva sponsoring wild oat tests from NSW and Queensland. Ten samples of wild radish were received as were samples of barley grass, phalaris, sow thistle, charlock and for the first time Paterson's curse (Table 1)

Table 1: Total number of samples received since 2018

	2018	2019	2020	2021
Annual ryegrass	115	97	52	141
Wild oats	37	23	19	139
Wild radish	13	21	6	10
Brome grass	3	0	0	0
Barley grass	2	0	1	3
Phalaris	0	0	0	4
Sow thistle	0	1	0	2
Charlock	0	0	1	1
Paterson's curse	0	0	0	1
Total	171	142	79	301

Summary of Results

The results obtained from the 2021 resistance screening are similar in the majority of cases to the results from previous years.

Annual ryegrass

This year, 141 annual ryegrass samples were received, of which 131 were tested to five or more herbicides (Table 2). However, only one of these was tested to the standard cross-resistance test (Hoegrass, Select, Glean, simazine and trifluralin) with no additions or changes, same as 2020 but with nearly three times the samples tested and in 2019 none were tested to the standard herbicides only. The most commonly requested herbicides for testing were Select and Roundup, requested for all but four samples, followed by trifluralin (119 samples). No other herbicide was tested to more than 55 samples showing the customisation of testing by growers or agronomists. Two samples were tested to only one herbicide (Roundup), both from roadsides, 10 were tested to three herbicides and two to four. Twenty-

five samples were tested to the standard cross resistance test number of five herbicides with 80 (over 50%) tested to six herbicides. Seven samples were tested to seven or nine herbicide, two to ten herbicides and six samples were tested to 11 different herbicides.

Of the 54 samples tested to a 'fop' herbicide 52 (96%) were classed as either resistant or developing resistance to that herbicide a similar level to most of the previous years (Table 3). As in usually the case in recent years, many samples were not tested to the 'fop' or Group B herbicides unless specifically requested by the client (Table 2). This may be the result of those clients from areas with a higher incidence of resistance requesting changes to the standard test to look for susceptible options and dropping the 'fop' and Group B test whereas clients from areas with lower resistance incidence are still confirming if the herbicides are still effective.

Table 2: Number of samples tested to each of seven herbicide groups

Group	2018	2019	2020	2021
1 A (fops)	42	16	13	54
1 A (dims)	132	137	71	166
1 A (dens)	32	7	6	38
2 B (SU)	56	13	17	61
2 B (Imi)	26	12	14	22
5 C	84	46	28	88
3 D	108	104	47	122
15 J	5	29	18	7
15 J/K	20	49	12	54
15 K	18	16	12	43
22 L	31	53	13	13
9 M	109	96	51	137

Nineteen percent of samples tested to a 'dim' herbicide were resistant, higher than most previous years (Table 3). The samples screened to 'dim' herbicides were screened to Select, Achieve and/or Factor. As is usually the case the proportion of samples resistant to Select and Factor was lower than for the other 'dim' herbicides tested. This year 9% of samples were resistant to Select and 26% to Factor, compared to 67% to Achieve (Table 6). Of the 38 samples screened to Axial 27 were resistant.

Seventy seven percent of samples were resistant to a sulfonylurea herbicide and 83% to an imidazolinone, a similar level to the majority of previous years (Table 3). As mentioned previously the proportion of samples being tested to the sulfonylureas is decreasing.

Table 3: Percentage of samples resistant or developing resistance to each herbicide groups

		2018	2019	2020	2021
1	A (fops)	92	94	92	96
1	A (dms)	40	26	45	19
1	A (dens)	94	100	100	71
2	B (SU)	84	46	77	77
2	B (Imi)	85	92	86	73
5	C	0	2	1	0
3	D	24	5	11	6
9	M	24	20	24	41

No samples were resistant to Group C, J, J/K, K or L herbicides this year. In previous years samples resistant to Groups C or L have been received. Six percent of samples were resistant to trifluralin, a level within the range of previous years (Table 3).

Probably the most concerning finding is the continued significant proportion of samples resistant to Roundup (Table 3; 7). For the third consecutive year over 20% of samples were resistant or developing resistance to this herbicide, one of the, if not the, most important herbicides available. A number of these samples have been provided from non-agricultural settings (eg. roadsides) which will increase the risk profile for resistance

Cross and Multiple Resistance

127 samples were screened to five or more herbicides with 120 of these screened to five or more herbicide groups. However, as many clients are now customising the testing to suit their circumstances only 36 samples were sprayed to the five standard selective herbicide groups ('fop', 'dim', B, C and D). Of these, none were susceptible to all groups, two were resistant to one group, 25 to two, eight to three and one to four groups.

Of the 21 samples tested to less than five herbicide groups seven were susceptible to all samples, whilst all but the two samples tested to only one herbicide were susceptible to one or more of the tested herbicides (Table 4).

The remaining 120 samples were tested to five or more groups, of these 20 (16.7%) were susceptible to all herbicide groups (Table 4). Thirty-seven (30.8%) samples were resistant to only one group while 29 (24.2%) were resistant to two, 29 (24.2%) to three groups, four (3.3%) to four groups and one (0.8%) to five groups (Table 4).

The level of cross and/or multiple resistance is much lower in these samples as in most cases the herbicide groups not tested are the A 'fops' and/or B. These groups have the highest level of resistance (Table 3)

suggesting that the farmers or their agronomists are acknowledging these populations are resistant to these groups and are investigating the susceptibility of alternative herbicide groups. With only 41 of the 120 samples that were screened to five herbicide groups tested to both 'fop' and B herbicides, it is probable that most of the other 79 samples would be resistant to an additional one or two herbicide groups.

Table 4: Number of groups samples were tested to in 2020 and the number of resistant groups

Resistant groups	Herbicide groups tested							
	1	2	3	4	5	6	7	8
0	0	1	3	3	12	8	0	0
1	2	2	4	3	21	11	2	3
2	0	0	1	2	13	12	3	1
3	0	0	0	0	4	20	1	4
4	0	0	0	0	1	1	0	2
5	0	0	0	0	0	1	0	0
Total	2	3	8	8	51	53	6	10

Herbicide Groups

Among all samples there were major differences between the various groups and in some cases within the different herbicide groups.

Group A (1) herbicides

While Select and Axial were the main herbicides tested, samples were also screened to Hoegrass, Verdict, Topik, Achieve and Factor (Table 5).

Table 5: Results for ryegrass samples showing percentage resistant (Res) or developing resistance (DR) to individual Group A (1) herbicides.

	Tested	Res	DR	%	Susc
<i>'fops'</i>					
Hoegrass	36	34	2	96	0
Topik	17	13	2	88	2
Verdict	1	1	0	100	0
<i>'dms'</i>					
Select	134	6	7	10	121
Achieve	24	13	3	67	8
Factor	8	1	1	25	6
<i>'den'</i>					
Axial	38	25	2	71	11

Group B (2) herbicides

While most of the samples screened to Group B herbicides were screened to Glean or Intervix, samples were also screened to Logran, Atlantis, Hussar, Crusader and Rexade (Table 6).

Table 6: Results for ryegrass samples screened to individual Group B (2) herbicides

	Tested	Res	DR	%	Susc
<i>Sulfonylureas</i>					
Glean	37	31	2	89	4
Logran	10	3	2	50	5
Hussar	11	5	1	55	1
Atlantis	3	3	0	100	0
<i>Imidazolinones</i>					
Intervix	22	11	5	73	6
<i>Sulfonamides</i>					
Crusader	18	17	1	100	0
Rexade	1	0	0	0	1

Other herbicides

Annual ryegrass samples were screened to 16 other herbicides, simazine, atrazine, Terbyne, trifluralin, Stomp, Kerb, Avadex Xtra, Arcade, Boxer Gold, Sakura, Gramoxone, Roundup, Basta, Amitrole T, Valor and Arsenal Super. The observed incidence of resistance to these herbicides was lower than the resistance to the higher risk Group A and B herbicides (Table 7).

Table 7: Results for ryegrass samples screened to other herbicide groups.

	Tested	Res	DR	%	Susc
<i>Group C (5)</i>					
Simazine	56	0	0	0	56
Atrazine	32	0	0	0	32
<i>Group D (3)</i>					
Trifluralin	119	5	2	6	112
Kerb	1	0	0	0	1
<i>Group J (15)</i>					
Avadex Xtra	6	0	0	0	6
<i>Group J/K (15)</i>					
Boxer Gold	54	0	0	0	54
<i>Group K (15)</i>					
Sakura	41	0	0	0	41
Dual Gold	2	0	0	0	2
<i>Group L (22)</i>					
Gramoxone	13	1	0	8	12
<i>Group M (9)</i>					
Roundup	137	41	15	41	81

Fifty six of the 137 samples tested to Roundup were found to be resistant or developing resistance. This herbicide needs to be treated carefully due to its importance in Australian agriculture. One sample was found to be resistant to Gramoxone this year (Table 7). No samples were resistant to any of the Group J or K herbicides or their mixture or to the Group D herbicide Kerb. Single samples were tested to Arsenal Super (B), Rexade (B+I), Terbyne (C), Kerb (D), Valor (G), Arcade (J), Basta (N) and Amitrole T (Q) all of which were susceptible. With significant levels of resistance to other herbicides

these herbicides are very important, and need to be managed well, through crop and herbicide rotations in conjunction with non-chemical weed control to maintain their effectiveness for as long as possible.

State by State

New South Wales and Western Australia supplied the most samples with samples also received from Tasmania, Victoria and South Australia (Table 8). The larger number of samples from Victoria and South Australia in 2017 was the result of the Syngenta Boxer Gold stewardship package with only two and six samples respectively from these states this year.

Table 8: Number of ryegrass samples received from each state.

	2017	2018	2019	2020	2021
NSW	109	52	21	14	101
Vic	65	3	2	3	2
SA	70	1	5	8	6
WA	188	56	69	22	29
Tas	6	3	0	5	2

With limited samples received from Victoria, South Australia and Tasmania only the data for New South Wales and Western Australia has been analysed separately (Figure 1) and then only for the herbicide groups where more than 10 samples were tested (A 'dims', D and M). There are minimal differences in the Group A 'dim' and D resistance levels, however the important difference is in the glyphosate resistance with nearly half (49%) of NSW samples resistant compared with 18% of WA samples nearly identical to last year (Figure 1).

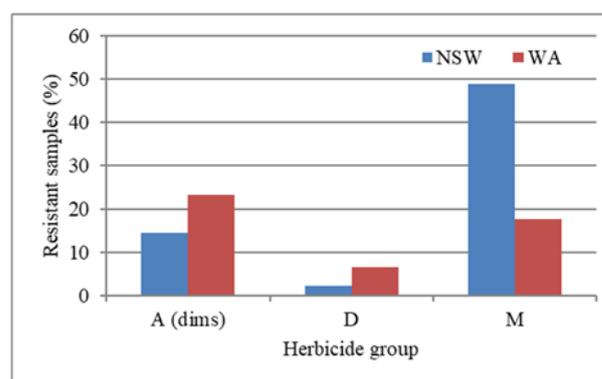


Figure 1: Percentage of ryegrass samples from NSW and WA resistant and developing resistance to selected herbicide groups

Wild Oats

The number of wild oat samples (139) received was the most ever received, higher than the 126 received when a total of 898 samples were received in 2002. On a percentage basis the number of samples was the highest ever (46.2%) the first-time wild oat samples

had comprised over 30% of samples received (Table 9). As normally occurs the vast majority of wild oat samples (122) were received from New South Wales with the other 17 samples from Queensland.

Table 9: Number of wild oat samples received and percentage of total samples

	2017	2018	2019	2020	2021
Total	498	170	142	78	301
Wild oats	31	37	23	19	1913
					9
Percentage	6.2	21.8	16.2	24.4	46.2

The level of 'fop' resistance among the samples was 71%, similar to previous years (Table 10). 125 samples were tested to Topik (93 resistant) and 17 to Verdict (7 resistant).

For the 'dim' herbicides, three of the 112 samples tested to Select were resistant while three out of 25 were resistant to Achieve. 112 samples were tested to Axial with 26 of these resistant (Table 10).

One of the samples tested to Atlantis (104) or Mataven (10) were classed as developing resistance, while all samples tested to Intervix (15), Hussar (1), Crusader (5), Rexade (8), Avadex (33), Boxer Gold (1) or Roundup (4) were susceptible.

Table 10: Percentage of wild oat samples found to be resistant since 2019 (number tested in brackets)

		2019	2020	2021
		% (no.)	% (no.)	% (no.)
1	A 'fops'	78 (18)	68 (19)	71 (142)
1	A 'dims'	18 (23)	13 (16)	4 (137)
1	A 'dens'	36 (14)	50 (8)	23 (112)
2	B	4 (27)	0 (21)	1 (125)

Broadleaf species

Ten wild radish samples were provided for resistance screening with nine from Western Australia and one from NSW.

Table 11: Percentage of wild radish samples found to be resistant since 2018 (no. of tests in brackets)

		2018	2019	2020	2021
		% (no.)	% (no.)	% (no.)	% (no.)
2	B	38 (8)	21 (19)	33 (3)	67 (6)
5	C	16 (18)	6 (35)	0 (5)	0 (9)
12	F	33 (12)	90 (20)	0 (6)	100 (9)
4	I	53 (15)	26 (23)	0 (7)	33 (12)
9	M	0 (10)	0 (19)	0 (4)	0 (2)

Resistance was detected to Glean (3/3), Logran (1), Brodal (9/9), Ester 80 (2/5) and MCPA LVE 570 (1/4). No samples were resistant to Intervix (2 tested), atrazine (5), bromoxynil (4), Jaguar (1),

Velocity (1), Tigrex (1), 2,4-D Amine (3) and Roundup (2) (Table 11).

Other species

Three barley grass samples were received, with resistance found to the Group A 'fops' (2/3) but not 'dims', B or M. Four annual Phalaris samples were tested these were all resistant to Verdict and Axial but all susceptible to Select and Atlantis.

Single samples of sow thistle (ST), charlock (Ch) and Paterson's curse (PC) were all resistant to the Group B herbicide they were tested to but not to Tigrex (ST & Ch), simazine (ST) and 2,4-D Amine (ST). Another sow thistle sample is at present being tested to Roundup.

Final Observations

- As normal NSW and WA supplied the most annual ryegrass samples and wild oats mainly received from NSW.
- For ryegrass samples the level of resistance remained similar to previous years for the major herbicide groups.
- For the fourth consecutive year over 20% of ryegrass samples were resistant or developing resistance to Roundup. This is a major concern.
- Wild oat resistance for all groups was within the range experienced in previous years.
- With the higher proportion of wild radish samples from Western Australia this year resistance levels increased.

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Testing forms and annual reports are available at:

<https://www.csu.edu.au/plantinteractionsgroup/herbicide-resistance>

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