# Integrated weed management: pre-sowing tactics are not sufficient for controlling herbicide resistant annual ryegrass in the high rainfall zone

**Corinne Celestina[1], Ed Hilsdon[1], Christopher Preston[2] and Gurjeet Gill[2]**
*[1] Southern Farming Systems*
*[2]University of Adelaide*

## Key messages

- Continuous cropping and a reliance on pre-sowing weed control measures is not an effective way to manage herbicide resistant annual ryegrass over the long term.
- The increase in weed numbers over time can be limited by adopting an intensive and high cost herbicide strategy, but this will not deplete the seed bank.
- Increasing annual ryegrass density was associated with decreased grain yield.

## Introduction

Grass weeds such as annual ryegrass have become critically important in winter grain crops in terms of their potential to limit productivity and therefore profitability. When untreated, yield losses can be up to 50-60% of a crop. In the high rainfall zone (HRZ) of Victoria annual ryegrass has become an issue of concern due to the increase in cereal cropping, short rotations, the move towards reduced or no tillage systems and the increased use of herbicides as the main weed control method.

This has put pressure on the use of selective herbicides and surveys of annual ryegrass populations across Australia's grain growing regions have revealed widespread resistance to post-emergent Group A, and B herbicides (Boutsalis et al. 2012). The use of Integrated Weed Management (IWM) tools is the best approach for managing herbicide resistance and for ensuring that the remaining herbicide options will be more useful for longer. This involves moving away from an exclusive reliance on herbicides and instead pursuing an integrated approach involving a mix of currently available effective herbicides and a range of non-herbicide practices.

This three-year trial aimed to assess the effectiveness and applicability of cultural control practices prior to crop seeding in combination with pre-emergent herbicides for the management of herbicide resistant annual ryegrass in the high rainfall zone of Victoria. The trial at the Southern Farming Systems' Lake Bolac research site is experimenting with a range of pre-sowing cultural control practices in combination with pre and post-emergent herbicides.

## Method

The trial combines four different cultural weed control options with three different herbicide treatments, so that in total there are 12 different strategies carried out over a three-year wheat/barley/canola rotation from 2012 to 2014. These treatments are detailed in Table 1 below.

Figure 1. Annual ryegrass germinating amongst wheat stubble after harvest at Lake Bolac

Table 1. The four different cultural control methods and three different chemical control regimes being trialled in combination at Lake Bolac to control herbicide resistant annual ryegrass. Herbicide strategies: A: low-cost; B: mid-cost; C: high cost. IBS = integrated by sowing.

| | | |
|---|---|---|
| **Cultural control treatments** | Mouldboard ploughing | |
| | Stubble burning | |
| | Stubble incorporation with light cultivation | |
| | Retained stubble with direct sowing | |
| **Chemical control treatments** | 2012 (wheat) | A. Trifluralin 2 L/ha + Dual Gold 250 ml/ha IBS |
| | | B. Boxer Gold 2.5 L/ha IBS |
| | | C. Sakura 118 g/ha + Avadex Xtra 1 L/ha IBS |
| | 2013 (barley) | A. Trifluralin 2 L/ha + Dual Gold 250 ml/ha IBS |
| | | B. Boxer Gold 2.5 L/ha IBS |
| | | C. Boxer Gold 2.5 L/ha IBS<br>Boxer Gold 1.5 L/ha @ GS11 ryegrass |
| | 2014 (RT canola) | A. Trifluralin 3 L/ha IBS<br>Atrazine 900 2.2 kg/ha + Select 0.5 L/ha @ 4 leaf canola |
| | | B. Trifluralin 3 L/ha IBS<br>Roundup Ready 0.9 kg/ha @ cotyledon<br>Roundup Ready 0.9 kg/ha + Atrazine 900 1.1 kg/ha @ 6 leaf canola |
| | | C. Trifluralin 3 L/ha IBS<br>Roundup Ready 0.9 kg/ha @ cotyledon<br>Roundup Ready 0.9 kg/ha + Atrazine 900 1.1 kg/ha @ 6 leaf canola<br>Weedmaster DST 3.5 L/ha @ prior to harvest |

The three stubble cultural control treatments (retain, incorporate and burn) were carried out annually in 2012 and 2013. Mouldboard ploughing was seen as a once-off intervention prior to sowing in 2012 and was followed by retained stubble in 2013. After harvest 2013 all treatments were harvested short and the stubble windrowed before the entire site, including windrows, was burnt.

Overlaid on the four seedbed management treatments were three different chemical control treatments. The three herbicide strategies were designed to range from a lower cost, standard district practice option (A ) to a mid-cost option (B) to the best available, highest cost strategy (C) (see Table 1 above). The aim was to use whatever existing and experimental chemistry was available for pre and post-emergent ryegrass control in each crop. At this site due to Group A and B herbicide resistance the chemical options in the wheat and barley crops were limited to those that can be applied prior to seeding and crop emergence.

The site was highly variable in ryegrass populations due to previous management. The site was therefore split into blocks of a minimum of 0.3 ha in size in order to layout the four cultural treatments. This was then replicated 4 times, meaning the total trial area is almost 5 ha. Ploughing and light cultivation occurred on 20 March 2012 and the whole trial was sown to Beaufort wheat on 8 June 2012. All chemical control treatments were incorporated by sowing (IBS) on that day. Crop establishment and the number of annual ryegrass seedlings were assessed 60 days after sowing (DAS) and at weed maturity 180 DAS an assessment of ryegrass heads was made.

In 2013 the incorporate plots were harrowed on 9 April and the burn plots burnt on 10 April. The site was sown to Westminster barley on 3 June with pre-emergent herbicides applied the same day and incorporated by sowing. The post-emergent application of Boxer Gold was made on 9 July when the barley was at the 2 to 3-leaf stage and ryegrass at the 1 to 2-leaf stage. Crop establishment and the number of annual ryegrass seedlings were assessed 60 days after sowing (DAS) and at weed maturity 180 DAS an assessment of ryegrass heads was made.

At the 2013 barley harvest all treatments were harvested to a height of 20 cm or less and the stubble was formed into narrow windrows. The entire site, including windrows, was burnt on 7 April 2014 and then all treatments were sown to Hyola 525 RT® canola on 13th May 2014 with the pre-emergent herbicides incorporated by sowing. Crop establishment and annual ryegrass numbers were assessed 30 DAS. The first post-emergent application went out in herbicide treatments B and C on 18 June at cotyledon stage of the canola and then ryegrass numbers were assessed for the second time at 60 DAS. The second post-emergent herbicide applications were applied on 21 July and 20 August targeting 4- and 6-leaf of the canola. This was followed by another assessment of annual ryegrass numbers at 120 DAS and then a final count of weed seed heads was completed just prior to crop topping on 19 November 2014, 180 DAS.

## Results

Table 2. Annual ryegrass population size and crop yield in 2012-2014. Means followed by the same letter do not differ significantly at $p$=0.05. DAS = days after sowing.

| Cultural treatment | Herbicide treatment | 2012 – Wheat (Beaufort) | | | 2013 – Barley (Westminster) | | | 2014 – Canola (Hyola 525 RT) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ryegrass 60 DAS (plants/m$^2$) | Seed heads 180 DAS (spikes/m$^2$) | Yield (t/ha) | Ryegrass 60 DAS (plants/m$^2$) | Seed heads 180 DAS (spikes/m$^2$) | Yield (t/ha) | Ryegrass 30 DAS (plants/m$^2$) | Ryegrass 60 DAS (plants/m$^2$) | Ryegrass 120 DAS (plants/m$^2$) | Seed heads (spikes/m$^2$) | Yield (t/ha) |
| Retain | * | 30 | 146 b | 7.80 | 112 a | 286 | 7.64 | 104 | 83 | 80 | 271 | 1.72 |
| Plough | * | 5 | 69 c | 8.09 | 37 b | 149 | 8.19 | 72 | 86 | 67 | 200 | 1.89 |
| Incorporate | * | 18 | 116 bc | 8.10 | 75 ab | 323 | 8.14 | 183 | 123 | 79 | 279 | 1.84 |
| Burn | * | 48 | 229 a | 7.82 | 96 a | 232 | 7.83 | 120 | 74 | 85 | 280 | 1.89 |
| ** | A (low cost) | 18 | 169 a | 7.80 | 119 a | 316 a | 7.77 | 151 a | 195 a | 82 | 320 a | 1.76 |
| ** | B (mid cost) | 26 | 175 a | 7.96 | 95 a | 302 a | 7.88 | 141 a | 62 b | 78 | 287 a | 1.83 |
| ** | C (high cost) | 30 | 76 b | 8.09 | 27 b | 124 b | 8.20 | 68 b | 17 b | 83 | 165 b | 1.92 |
| Retain | A (low cost) | 14 | 215 | 7.61 | 201 a | 377 | 7.42 | 187 b | 174 bc | 82 | 360 | 1.54 |
| | B (mid cost) | 26 | 166 | 7.62 | 123 b | 386 | 7.19 | 95 cde | 63 d-g | 74 | 301 | 1.76 |
| | C (high cost) | 49 | 56 | 8.15 | 12 f | 95 | 8.32 | 29 f | 12 fg | 82 | 152 | 1.87 |
| Plough | A (low cost) | 4 | 107 | 8.10 | 73 b-e | 221 | 8.28 | 103 cde | 220 ab | 81 | 279 | 1.81 |
| | B (mid cost) | 4 | 65 | 7.98 | 29 ef | 160 | 7.98 | 80 def | 33 efg | 59 | 189 | 1.97 |
| | C (high cost) | 8 | 36 | 8.18 | 10 f | 65 | 8.33 | 34 f | 5 g | 60 | 131 | 1.90 |
| Incorporate | A (low cost) | 14 | 125 | 8.13 | 88 bcd | 398 | 8.10 | 167 b | 272 a | 89 | 336 | 1.76 |
| | B (mid cost) | 19 | 113 | 8.09 | 104 bc | 351 | 8.13 | 246 a | 69 def | 80 | 307 | 1.82 |
| | C (high cost) | 21 | 112 | 8.09 | 35 def | 221 | 8.20 | 136 bcd | 27 efg | 69 | 194 | 1.94 |
| Burn | A (low cost) | 43 | 231 | 7.37 | 116 b | 269 | 7.30 | 146 bc | 115 cd | 75 | 305 | 1.92 |
| | B (mid cost) | 55 | 356 | 8.15 | 122 b | 311 | 8.22 | 142 bc | 84 de | 99 | 351 | 1.77 |
| | C (high cost) | 45 | 101 | 7.94 | 50 c-f | 117 | 7.98 | 74 ef | 23 efg | 81 | 184 | 1.97 |

* averaged across herbicide treatments
** averaged across cultural treatments

**Wheat in 2012**

There are no post-emergent herbicides available for wheat and no practical seed set control tactics for this environment, so annual ryegrass control relied on pre-sowing cultural practices and pre-emergent herbicides as detailed in Table 1.

In 2012 there was no significant effect of cultural management practice on ryegrass plant population after establishment but there was a significant impact on weed seed heads at maturity (Table 2). Mouldboard ploughing had significantly fewer seed heads than either the stubble retained or burnt treatments; this treatment was also observed to have greater germination of wild radish than any other treatment (data not shown).

Among the herbicide treatments there was a significant reduction in annual ryegrass seed head production for the high cost option of Sakura plus Avadex Xtra compared to the lower cost options of Trifluralin plus Dual Gold or Boxer Gold.

There was no significant effect of cultural or chemical management practice on crop yield, although higher yields were generally associated with lower weed populations.

**Barley in 2013**

Again there were no registered post-emergent herbicide options available for annual ryegrass and no seed set control options, so the same strategy as in 2012 was employed. As Sakura will not be registered for barley, the option of including an early post-emergent application of Boxer Gold (likely to be registered in 2015) was chosen to provide extra annual ryegrass control.

In 2013, there was a significant reduction in annual ryegrass germination in the mouldboard plough treatment compared to the stubble retain and stubble incorporated treatments. Although there were also fewer seed heads at maturity, this was not significant. Mouldboard ploughing in 2012 was followed by retained stubble in 2013; the resulting high trash loads likely reduced the efficacy of pre-emergent herbicides and allowed weed numbers to recover somewhat.

As in 2012 the high cost herbicide option C resulted in significantly lower annual ryegrass densities compared to the other two cheaper options, regardless of which cultural control practice was used. The strategies with the highest number of weeds germinating were the retain stubble, incorporate stubble and burn treatments using the low and mid-cost herbicide options. These differences were likely related to better control by the herbicides in treatments with high stubble loads, particularly where stubble and ryegrass seed was incorporated.

As in 2012 there were no significant differences in crop yields across the trial but once again the higher yields did tend to occur where weed pressure was lower.

**Canola in 2014**

In 2014 canola was sown after windrowing and burning the entire site. An RT canola variety, Hyola 525 RT®, was chosen which combines Roundup Ready technology with Triazine Tolerant to offer two post-emergent herbicide options for ryegrass control.

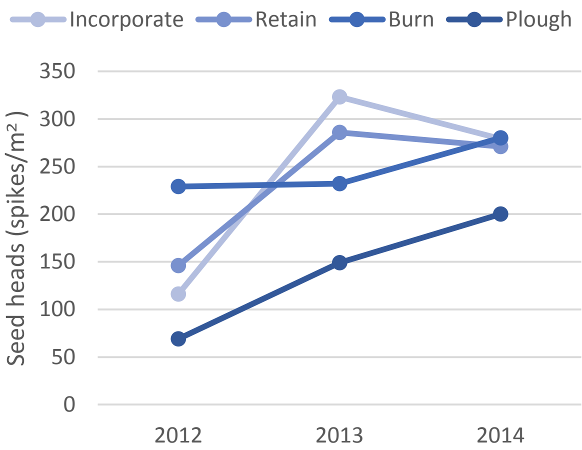
There was no significant impact of cultural practice on ryegrass numbers during the season or crop yields. Mouldboard ploughing generally had fewer weeds germinating and producing seed heads but it was not significantly better than any other cultural control treatment.

However, there were significantly fewer ryegrass seedlings establishing and setting seed under the more expensive herbicide strategy C compared to A and B. Crop yields also tended to be better under the more expensive herbicide regime but not significantly so. The lowest numbers of ryegrass at establishment and crop maturity occurred where the most expensive herbicide strategy had been employed for three years in row, followed by intermediate weed populations under strategy B and the highest weed numbers under the low-cost option A.

## Conclusion

Overall, the population of annual ryegrass increased between 2012 and 2014, even for the most intensive strategies (Figure 2). This indicates that continuous cropping – and a reliance on cultural and chemical management at the beginning of the season – is not an effective way to manage herbicide resistant annual ryegrass populations in this environment.

The lack of effective seed set control options in these crops in a high rainfall environment means that populations will continue to increase as late-in-crop weeds escape earlier attempts at control. This increase can be limited by adopting an intensive and high cost herbicide strategy, but this is insufficient to bring annual ryegrass populations down.



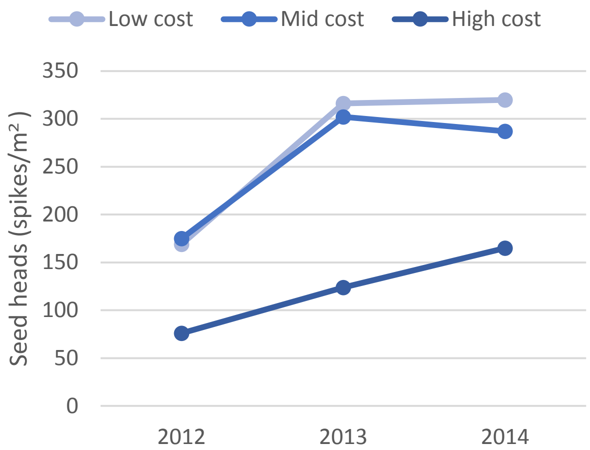




Figure 2. Annual ryegrass seed heads under the four different cultural control treatments (left) and three different herbicide treatments (right) from 2012 to 2014.

Mouldboard ploughing can be effective at reducing the annual ryegrass seed bank (Douglas and Peltzer 2004). However, at this site, mouldboard ploughing did not eliminate the annual ryegrass and where lax management followed the plough, weed numbers rapidly increased. Rotations that have the option of seed set control every year are essential to reduce annual ryegrass seed banks.

Higher annual ryegrass populations were consistently associated with decreased grain yield. For every 100 seed heads per square metre there was a 2.5% reduction (or 100-250 kg/ha decrease) in grain yield.

## Acknowledgements
Neil Vallance, trial site landholder; all SFS staff and casuals, past and present, who assisted in the trial including: Megan Beveridge, Paul Breust, Jim Caldwell, Adam Felthouse, Ed Hilsdon, Jade Killoran, Gina Kreeck, Hayden McCrow, Tom Portier, Gary Sheppard and Elaina vander Mark.

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