Eleven years of narrow row spacing – higher yield and fewer weeds

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Key messages

An 11 year study showed that narrow row spacing and harvest weed seed destruction (i.e. residue burning each autumn) reduced annual ryegrass seed production.

Over 11 years, narrow row spacings had greater crop yield and reduced annual ryegrass seed production. At row spacings of 9, 18, 27 and 36cm, average yield was 1.66, 1.64, 1.55 and 1.49 t/ha. Average annual ryegrass seed at harvest was 58, 78, 223 and 333 seeds/m^2.

Residue burning reduced average crop yield compared to unburnt plots (1.53 and 1.64 t/ha). However, burning residue reduced annual ryegrass seed at harvest (57 and 297 seeds/m^2 in the burnt and unburnt plots).

Aims

There are clear economic advantages to integrated weed management (IWM) in the long term, to managing herbicide resistance (Jones & Monjardino, 2006). However, to be practical for growers to adopt, IWM programs need to be simple to implement and inexpensive in the short term as well as beneficial in the long term. Examples of simple, inexpensive weed control techniques include reduced crop row spacing and weed seed destruction at harvest. Reduced row spacing improves the competitive ability of the crop and so reduces weed growth and will also generally increase yield in the absence of weeds (Scott et al, 2013). This increased crop yield easily offsets the minor cost of this technique (from increased fuel usage and a slight increase to the time of sowing), making narrow row spacing economically desirable even in the absence of weeds (Scott et al, 2013). Harvest weed seed destruction may be achieved using a Harrington seed destructor or chaff cart (Walsh et al, 2013). The cost includes an initial investment in machinery, mechanical operation, delayed harvest, fire risk (if burning chaff dumps) and lost nutrients if chaff is removed or burnt (Jones & Monjardino, 2006). Alternatively, weed seeds may be destroyed by burning all residue, or windrow burning (Walsh et al, 2013). The cost of burning residue includes labour, management of the fire risk and lost nutrients (Storrie, 2014).

A study was conducted over 27 years, from 1987 to 2013, to determine the long term impacts of crop row spacing and crop residue burning on yield. Within this trial herbicides were applied according to regional practices, to control broad-leaved weeds (mainly *Sisymbrium orientale* L., Indian hedge mustard) and annual ryegrass (*Lolium rigidum* L. Gaud.). A chaff cart collection system was also utilised in some years. While broad-leaved weed control was successful, annual ryegrass was still found in the trial. The current research utilised data from the final 11 years of this trial (2003 to 2013), to determine the long term impact of crop row spacing and crop residue burning on annual ryegrass seed production.

Method

A trial was run from 1987 to 2013, at the Department of Agriculture and Food Western Australia Merredin Research Station, in a red clay-loam sandy salmon gum/gimlet soil. Treatments included crop row spacings (9, 18, 27 and 36cm) and crop residue management (residue burnt prior to crop seeding or unburnt). The trial was established as a randomised block design with six replications (plot size of 5m by 30m), but treatments were not re-randomised in each subsequent year. To implement the burnt residue treatment, crop residue from the prior year was burnt over the entire plot in autumn. The current study utilised data from 2003 to 2013, as this was the period of the trial during which annual ryegrass seed production was measured. Crops were sown using a no tillage seeding system (knife points and press wheels), and fertiliser applied at seeding (Agras®, Double Phos® or Double Super®). In 2008 the field was a chemical fallow due to low rainfall. All herbicides used to control annual ryegrass are listed in Table 1. Broad leaf selective herbicides applied in the trial are not included, as they successfully controlled Indian hedge mustard and did not affect the annual ryegrass or the crop. Herbicide control of annual ryegrass was inadequate, and by 2003 there was dense annual ryegrass in the trial, particularly in the wide row spacing, unburnt plots. Harvests were conducted in November or December, using crop lifters. A Rytec™ chaff system was utilised at harvest in all plots in the trial from 2003 to 2006.

Table 1: The sowing date, crop cultivar, sowing rate, herbicide use for annual ryegrass control, annual rainfall for the Merredin Research Station and growing season (May to October) rainfall, from 2003 to 2013 (from Merredin Research Station weather station number 010093). Note that + is used to indicate two herbicide products that were combined into a single tank mixture at the time of application.

Sowing date, crop (and sowing rate)	Herbicide and date of application	Annual rainfall/ growing season rainfall (mm)
4/6/03: wheat cv. Wyalkatchem (99 kg/ha)	1/5/03: 1 L/ha RoundupCT® Extra 28/5/03: 2 L/ha RoundupCT® Extra 4/6/03: 1 L/ha TriflurX® + 2 L/ha Spray.Seed® 29/7/03: 1.5 L/ha Spear®	356/278
3/6/04: wheat cv. Westonia (101 kg/ha)	2/6/04: 2 L/ha TriflurX® + 2 L/ha Spray.Seed® 20/7/04: 1.5 L/ha Spear®	279/210
2/6/05: field pea (*Pisum sativum* L.) cv. Kaspa (160 kg/ha)	15/4/05: 2 L/ha Spray.Seed® 2/6/05: 1 L/ha TriflurX® + 2 L/ha Spray.Seed® 25/7/05: 250 mL/ha Select®	305/240
8/6/06: wheat cv. Bonnie Rock (100 kg/ha)	25/1/06: 30 mL/ha Hammer® + 1 L/ha RoundupCT® Extra 10/5/06: 30 mL/ha Hammer® + 1 L/ha RoundupCT® Extra 8/6/06: 1 L/ha TriflurX® + 2 L/ha Spray.Seed® + 200 mL/ha DualGold® 21/8/06: 1 L/ha Decision®	330/154
26/6/07: barley cv. Hamlin (101 kg/ha)	26/6/07: 1 L/ha TriflurX® + 2 L/ha Spray.Seed® 13/8/07: 1 L/ha Decision®	230/163
5/5/08: chemical fallow	5/5/08: 2 L/ha Spray.Seed®	313/212
15/6/09: canola cv. Tanami (5.3 kg/ha)	15/6/09: 1 L/ha TriflurX® + 2 L/ha Spray.Seed®	290/195
3/6/10: wheat cv. Mace (75 kg/ha)	3/6/10: 1 L/ha TriflurX® + 2 L/ha Spray.Seed® 2/8/10: 380 g/ha Achieve®	168/139
7/7/11: wheat cv. Magenta (72 kg/ha)	7/7/11: 2 L/ha Roundup® PowerMAX + 2.4 L/ha Boxer Gold® + 25 mL/ha Hammer® 26/7/11: 380 g/ha Achieve®	400/255
18/6/12: chickpea (*Cicer arietinum* L.) cv. Slasher (136 kg/ha)	15/6/12: 1 L/ha Spray.Seed® + 1 L/ha Simazine Hi-Load® 24/7/12: 250 mL/ha Select®	290/136
28/5/13: wheat cv. Mace (97 kg/ha)	13/5/13: 2 L/ha Roundup® Attack™ 28/5/13: 2 L/ha Spray.Seed® + 120 g/ha Sakura®	353/224

Measurements and statistical analysis

Crop plant density was measured using two 46cm by 108cm quadrats per plot, four to six weeks after crop emergence. Crop yield was assessed by harvesting the centre of each plot (1.62m by 30m). Annual ryegrass seed production was assessed annually, although the method of assessment varied over the 11 year period. Full details of annual ryegrass seed production assessment can be found in Borger et al (2016).

The crop density, crop yield and annual ryegrass seed production variates were analysed with a linear mixed model for repeated measurements (REML procedure, GenStat 16th edition, VSN International, 2012). Full details of the analysis can be found in Borger et al (2016). Least significant difference (Lsd) was used to separate means of crop yield and standard error (SE) of the difference was used to separate annual ryegrass seed data.

Results

Crop plant density and yield

Crop density varied significantly between years, as different crops were sown at different rates, but was not affected by residue or spacing (data not presented). Average yield was greater in the unburnt plots (1.64 and 1.53 t/ha in the unburnt and burnt plots, P <0.001, Lsd: 41). This was due to increased yield in the unburnt plots in 2003, 2007, 2011 and 2013, although yield was reduced in the unburnt plots in 2005 (Table 2). Average yield also significantly increased at narrower row spacing, although the relationship was not linear in every year (1.66, 1.64, 1.55 and 1.49 t/ha in the 90, 180, 270 and 360cm row spacing treatments, P <0.001, Lsd: 589). Exceptions to this trend included 2012 and 2013, where the difference was not significant from 9 to 36cm. The interaction between crop residue and row spacing treatments, and the interaction between residue, spacing and year, were not significant.

Table 2: Average crop yield (t/ha) in the burnt and unburnt residue treatments (P <0.001, Lsd: 92) and the row spacing treatments (P <0.001, Lsd: 130), from 2003 to 2013.

Year	Crop	Crop residue		Row spacing			
		Burnt	Unburnt	9 cm	18 cm	27 cm	36 cm
2003	Wheat	2.90	3.44	3.21	3.32	3.10	3.05
2004	Wheat	1.76	1.73	1.82	1.83	1.76	1.56
2005	Field pea	1.94	1.80	2.00	2.02	1.76	1.71
2006	Wheat	2.47	2.43	2.59	2.63	2.36	2.22
2007	Barley	0.34	0.46	0.37	0.39	0.39	0.44
2008	Chemical fallow	0	0	0	0	0	0
2009	Canola	0.86	0.85	0.93	0.89	0.83	0.77
2010	Wheat	1.09	1.10	1.27	1.08	0.99	1.03
2011	Wheat	1.89	2.18	2.14	2.06	1.97	1.98
2012	Chickpea	0.16	0.14	0.18	0.15	0.12	0.14
2013	Wheat	1.90	2.27	2.08	2.02	2.20	2.04

Annual ryegrass seed at harvest

Average annual ryegrass seed production was lower in the burnt plots, with 56 and 296 seeds/m^2 in the burnt plots and unburnt plots (P: 0.005, SE: 1.5). Seed density was greater in the wide row spacing treatments, with 57, 77, 222 and 332 seeds/m^2 in the 9, 18, 27 and 36cm row spacing treatments (P: 0.014, SE: 2.9). There was a significant interaction between year, crop residue and row spacing. The annual ryegrass seed density was generally greater in wide row spacing treatments, although the relationship between seed density and row spacing was not linear in every year (Table 3). However, in the burnt plots, there was no significant difference between row spacing treatments by 2010 as the annual residue burning had reduced seed production to very low levels.

Annual ryegrass seed production was exceptionally high in 2009. Pre-seeding and non-selective herbicides were applied at seeding, and successfully killed annual ryegrass (Table 1). However, a very dense annual ryegrass cohort emerged late in the season. The canola crop was already flowering, and so it was too late to allow use of a selective herbicide.

Table 3: Annual ryegrass seeds/m^2 in the burnt and unburnt treatments, at a row spacing of 9 to 36cm, from 2003 to 2013 (P <0.001, SE: 20.9).

Year	Crop	Burnt				Unburnt			
		9 cm	18 cm	27 cm	36 cm	9 cm	18 cm	27 cm	36 cm
2003	Wheat	120	117	170	141	324	296	702	382
2004	Wheat	42	117	213	313	318	312	757	1001
2005	Field pea	147	221	354	1101	375	558	1930	1581
2006	Wheat	5	5	22	13	14	18	29	27
2007	Barley	6	23	28	105	25	54	424	789
2008	Chemical fallow	0	0	0	0	0	0	0	0
2009	Canola	55	152	159	622	140	319	3056	3468
2010	Wheat	3	1	6	17	17	24	36	173
2011	Wheat	2	0	0	17	159	162	334	552
2012	Chickpea	3	0	4	10	60	50	135	287
2013	Wheat	0	5	0	0	2	1	51	171

Conclusion

Burning stubble was a highly effective method of weed control, reducing annual ryegrass seed production to close to zero by the end of the 11 year management period. Removing the crop residue through burning is also likely to have improved the efficacy of the pre-emergent herbicide. Where crop residue is left on the soil surface, the pre-emergent herbicide may bind to the residue and the minimal soil disturbance in the no tillage system ensures that the residue and herbicide are not fully incorporated into the soil (Chauhan et al, 2006). As stated in the methods, burning was performed over the entire plot area, and caused a yield reduction (possibly due to reduced soil moisture retention). However, harvest weed seed destruction has made significant progress since 1987. Alternative methods are now available that will destroy annual ryegrass seed more effectively than burning the entire field, without causing a reduction to yield (Walsh et al, 2013).

This research demonstrates the long term benefits of narrow row spacing to reduce annual ryegrass seed production. While narrow row spacing is generally accepted as a method to increase the competitive ability of crops and suppress weed growth, the benefits of narrow row spacing have not been demonstrated in all studies (reviewed by Scott et al, 2013). However, most row spacing trials occur in a single year, on a site with an evenly distributed weed seed bank, and prior studies have generally assessed annual ryegrass biomass rather than seed production. The major difference in the current study is that the row spacing treatments had been established for 16 years prior to 2003 when annual ryegrass seed production was first assessed. The trial demonstrates that higher weed seed production occurs in the wide row spacing plots, leading to a higher weed seed bank in sequential years. The reduction in weed seed at narrow row spacing likely resulted from improved crop competition (Scott et al, 2013). However, narrow row spacing would also result in increased soil disturbance at seeding compared to wide row spacing, which would improve the performance of pre-emergent herbicides (Chauhan et al, 2006).

Crop yield was reliably increased at narrow row spacing. This is partially due to reduced weed competition, but narrow row spacing increases crop yield in the absence of weeds, due to canopy closure at an earlier stage, increased light interception, reduced evaporation and reduced intra-species competition for resources (Scott et al, 2013). Prior research has indicated that crops with wide row spacing may have more soil moisture available at maturity and so have higher yields in dry seasons (Blackwell et al, 2006; Scott et al, 2013). In the current trial, a significant yield increase was not observed in the dry years (notably 2007 and 2010). However, the increased annual ryegrass density in the wide rows may have negated any advantage of increased soil moisture as the weeds would compete with the crop and utilise stored soil moisture prior to crop maturity. Very narrow row spacing is not viable in high yielding areas, where the resulting crop residue is difficult to manage during the subsequent seeding operation. However, modern machinery has improved the ability of growers to achieve narrow rows, and growers can reassess their chosen crop spacing. While growers may not want to use 9 cm spacing, any reduction in their current spacing will increase crop yield and reduce weed seed production. For row spacing, every centimetre counts!

Key words

Narrow row spacing, residue burning, annual ryegrass, chaff cart.

Acknowledgments

Thanks are due to the managers and staff at the Department of Agriculture and Food Western Australia Merredin Research Station, who have assisted with this trial from 1987 onwards, particularly for the careful burning. Thanks are also due to Mr Cameron Wild, for processing annual ryegrass seed samples from 2011 to 2013. This paper was kindly reviewed by Peter Newman and Sally Peltzer.

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