Harvest weed seed control: ryegrass seed retention levels in south-eastern Australia wheat crops

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Abstract
Herbicide resistant weeds are a major impediment to Australian grain production and solutions to this problem are required. One of the newer methods used to reduce their impact is the collection and/or destruction of weed seeds at harvest, harvest weed seed control (HWSC). A major premise of HWSC is that the targeted weed species retain a high proportion of their total seed production at crop maturity and that this seed is subsequently collected during harvest. The adoption of HWSC systems in Western Australia has been driven by high annual ryegrass seed retention levels recorded in wheat production systems. The lack of seed retention data is likely restricting adoption of these systems across the Southern region cropping systems. To determine annual ryegrass seed retention levels in southern region, sampling was undertaken in 2013 within seven days of crop maturity (first opportunity to harvest) in 46 wheat crops located across southern NSW and Victoria. At each location wheat and annual ryegrass dry matter production, grain yield and weed seed number was determined for each of five cutting heights (0,10, 20, 30 and 40 cm) as well as from the soil surface. Overall, 80% (48-100%) of ryegrass seed was found at greater than 10 cm above the soil surface and 69% (23–100%) above 20 cm indicating that HWSC can be a valuable tool for NSW and Victorian farmers in reducing weed seed burdens. However, with the large variability shown between locations in this study the efficacy of HWSC will vary considerably.

Key words
Herbicide resistance management

Introduction

A significant proportion of crops grown across the cereal growing regions of southern New South Wales and Victoria contain herbicide resistant annual ryegrass populations with many of these resistant to multiple herbicide modes of action (Boutsalis, et al. 2012; Broster, et al. 2011; Broster, et al. 2013). With herbicides the dominant weed control method the risk of herbicide resistance evolution is high posing a significant threat to the few remaining effective herbicides. As a result both farmers and researchers are investigating alternate methods of weed control that reduce the reliance on herbicides.

Many of the major annual weeds of Australian cropping retain their seed at maturity (Walsh and Powles 2014) and this has been identified as a key weakness of these species that can be utilised by farmers to prevent seed bank inputs. While the harvest process is an important factor in the spread of weed seeds across the paddock (Blanco-Moreno, et al. 2004) it can also be an opportunity to restrict their contribution to the seed bank. A number of HWSC systems have been developed to target weed seed during the harvest process thereby reducing inputs into the seed bank. These include narrow windrow burning, chaff carts and the Harrington Seed Destructor (Walsh, et al. 2013). A major principle of these systems is that the proportion of weed seeds that are collected at the front of the harvester indicates the amount of weed seed they prevent from entering the seed bank.

HWSC systems have been extensively adopted by farmers in Western Australia as a result of the high levels of herbicide resistance in both annual ryegrass and wild radish found across the WA cropping regions (Owen, et al. 2014; Walsh, et al. 2007). Adoption has been slower in south-eastern Australia for a number of reasons, one of which has been the lack of localised data. This study aimed to address one of these issues, the height at which ryegrass seed was located within a wheat crop; this determines the harvest height necessary to collect the majority of weed seeds and thereby indicating the maximum potential benefit from HWSC systems.

Materials and Methods

Between October and December 2013, 46 wheat crops grown in a range of environments (low rainfall - irrigated) were sampled across southern New South Wales and Victoria (Figure 1). At each site wheat and annual ryegrass plants were collected from four, 1.0 m^2 quadrats at five cutting heights, 0, 10, 20, 30 and 40 cm above the soil surface at the time of wheat crop maturity (first opportunity to harvest). Additionally, the soil surface within quadrat area was swept with a brush to collect any seed, seed heads and plant material that had fallen from plants. The number of wheat and ryegrass plants were also counted in each quadrat.

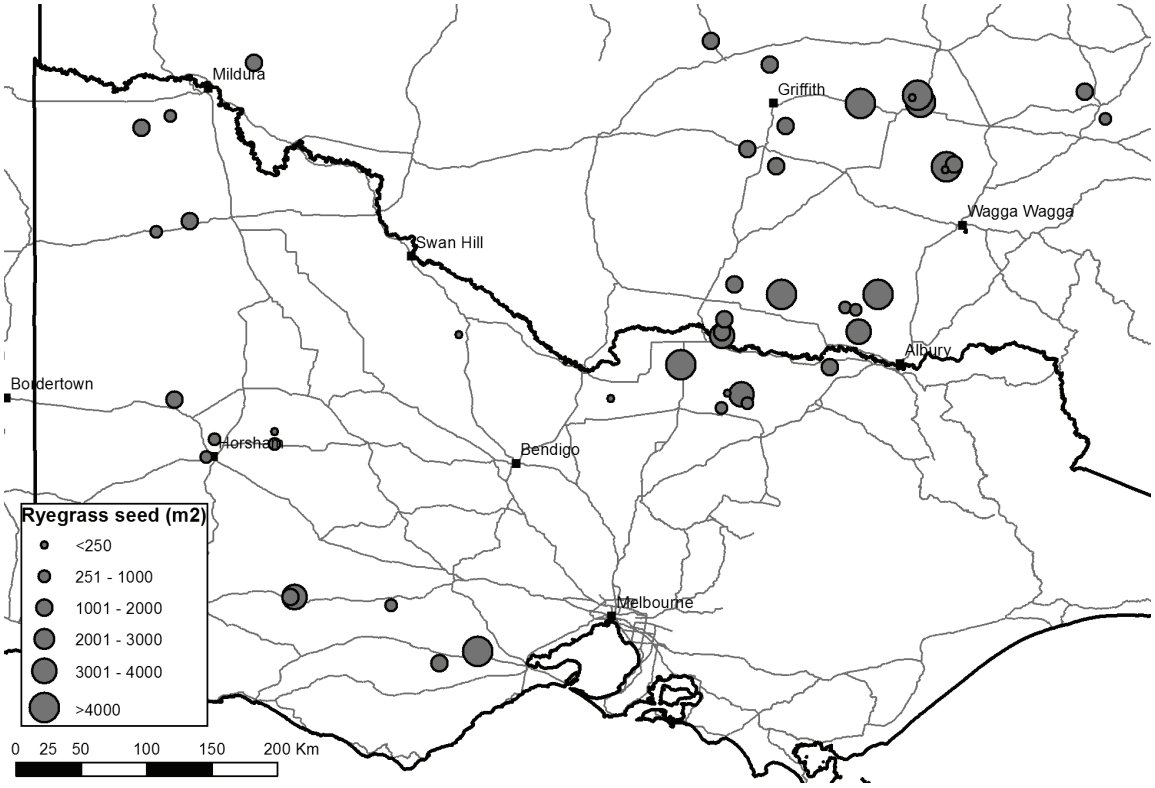

Figure1: Location of paddocks sampled across Victoria and southern NSW for the determination of annual ryegrass seed retention height at wheat crop maturity showing ryegrass seed densities at each site.

Before processing, the collected plant samples were oven dried at 70°C for 48 hours and then weighed. The samples were then sorted to separate wheat and ryegrass plant material. Any wheat heads present at each sample height were threshed and weighed to determine crop yield and proportion of yield at each sampling height. The ryegrass samples were weighed to determine dry matter production, threshed and then the seed produced was counted to determine seed production at each sampling height.

The percentage of ryegrass seed collected above each of the harvest heights was calculated for each site. For each variable measured the lowest and highest fifteen sites were then determined and the mean percentage of ryegrass collected above each harvest height was also determined for these sub-samples of sites. Standard errors were then calculated for the overall mean, lowest 15sites and highest 15 sites to allow the observation of differences between these categories.

Results

The mean wheat density was 65.6 plants/m^2 (range 13.0 – 122.25) producing 8.6 t/ha of dry matter (1.6 – 16.4) and 3.68 t/ha of grain (0.5 – 8.6) with a mean harvest index of 41.3%. The average number of ryegrass plants recorded was 8.5/m^2 (1.0 – 50.8) producing 168 kg/ha of dry matter (6 – 1145) and 1889 seeds/m^2 (87 – 7192) or approximately 18.9 million seeds per hectare.

Overall 93% of the ryegrass seed had been retained by the plants at the time of sampling, 80% (range 48-100) was above 10 cm and 69% (range 23-100) above 20 cm. As estimated from the plotting of height against seed production, at a 15cm harvest height there was no difference in the proportion of ryegrass seed

collected between the mean (75%), lowest (76%) and highest (75%) yielding sites (Figure 2a). However, a higher percentage of ryegrass seed was found above both 30 and 40 cm harvest heights in the higher yielding crops compared with both the overall mean and the lowest yielding crops (Figure 2a). A similar finding was also recorded for the sites with the lowest and highest wheat dry matter production.

Table 1: Wheat and ryegrass production across 46 sites in south eastern Australia

	Mean	Minimum	Median	Maximum
Wheat				
Plants (no./m^2)	65.6	13.0	65.6	122.3
Dry matter (t/ha)	8.6	1.6	8.2	16.4
Yield (t/ha)	3.7	0.5	3.2	8.6
Harvest index (%)	41.3	16.7	41.6	57.5
Ryegrass				
Plants (no./m^2)	8.5	1.0	4.3	50.8
Dry matter (kg/ha)	168	6	90	1145
Seed production (seed/m^2)	1889	87	1254	7192

A greater percentage of ryegrass seed at all harvest heights was recorded in the paddocks with lower ryegrass densities when compared with paddocks with higher annual ryegrass plant density. In the paddocks with the highest annual ryegrass densities less seed (66.4%) was found above a 15 cm harvest height compared with the paddocks with lowest annual ryegrass plant densities (80.1%) (Figure 2b). Conversely, high annual ryegrass dry matter production or annual ryegrass seed production resulted in higher percentages of seed found at all heights compared with the overall mean, there were minimal differences between the low wheat production paddocks and the mean.

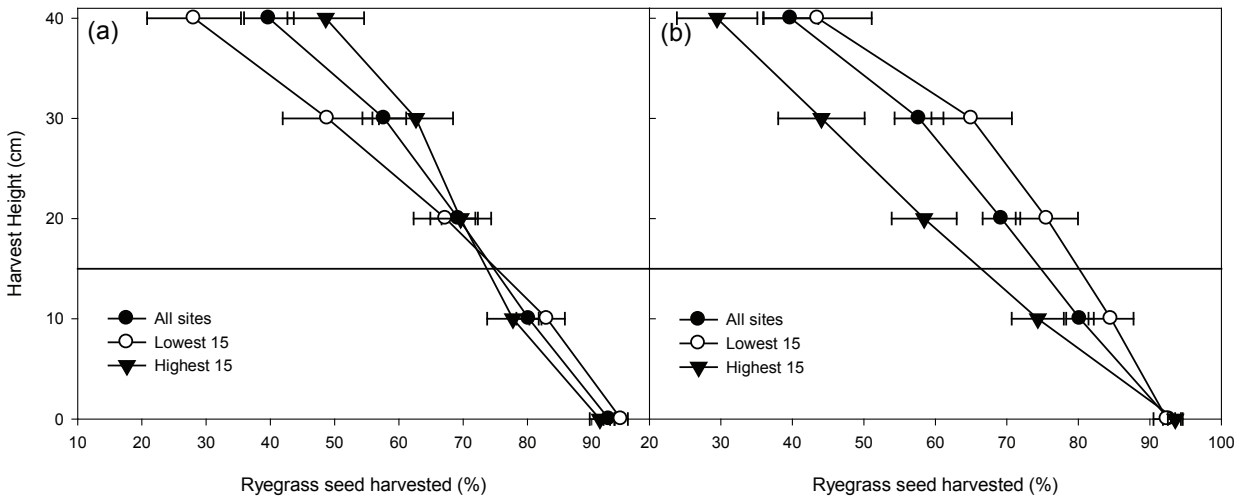

Figure 2: Percentage of annual ryegrass seed located above five harvest heights (0, 10, 20, 30 and 40 cm) for wheat yield (a) and ryegrass plant number (b). Lines represent the mean (± SE) for all sites, the 15 lowest sites and the 15 highest sites for each parameter. The horizontal line indicates a 15 cm harvest height, the standard for HWSC in Western Australia.

Lowering the harvesting height by 10 cm resulted in a greater than 10% increase in the amount of ryegrass seed collected. The associated increase in wheat dry matter collected was less than 10% and at least 90% of this was straw or leaf material and not chaff or grain (Table 2).

Discussion

The high proportions of annual ryegrass seed retention on upright tillers at wheat crop maturity determined that a harvest height of 15cm allowed the collection of 75% of total annual ryegrass seed production. However, there was considerable variation in annual ryegrass seed retention height associated with wheat biomass production. The optimum conditions for annual ryegrass seed collection occurs in higher yielding crops. Higher yielding crops have greater levels of dry matter production forcing annual ryegrass plants to

grower taller to compete for light and consequently producing seed higher in the crop canopy. That lower annual ryegrass numbers were also related to a higher potential for ryegrass seed collection agrees with previous research that found lower pre-harvest ryegrass seed numbers also had larger proportional reductions in plant density the next season (Walsh, et al. 2014).

Table 2: Average wheat dry matter production, wheat yield and annual ryegrass seed collected at five harvest heights for 46 sampling sites across Victorian and NSW. Numbers in brackets indicate % of total.

Harvest height (cm)	Wheat DM* t/ha (%)	Wheat yield* t/ha (%)	Ryegrass seed* no. (%)
0	0.80 (9.4)	0.02 (0.4)	223 (12.5)
10	0.66 (7.6)	0.01 (0.3)	207 (11.6)
20	0.62 (7.2)	0.01 (0.4)	207 (11.6)
30	0.77 (7.8)	0.05 (1.4)	302 (16.9)
40	5.83 (68.0)	3.58 (97.5)	847 (47.4)

* Dry matter and seeds found on the soil surface excluded from calculations.

A major concern raised by farmers when discussing HWSC systems is the need to harvest lower than normal and dramatically slowing the harvest operation. As observed in this study the majority of wheat grain (98%) was located above 40 cm however, the majority of annual ryegrass seed production (88%) occurred above 10 cm. At a 40 cm harvest height approximately 5.8 t/ha of biomass, 60% of which is grain, is processed. Here we found that the majority of additional crop material entering the harvester by harvesting at 10 cm instead of 40 cm is straw and leaf material only (Table 2) which requires minimal processing when compared with wheat heads.

This research has shown that HWSC systems have potential to be a useful management tool for NSW and Victorian farmers in reducing both weed seed burdens and their reliance on herbicides. However the large variability shown in this experiment its effectiveness will vary depending upon location, crop yield and ryegrass density.

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