Harvest weed seed control: the influence of harvester set up and speed on efficacy in south-eastern Australia wheat crops

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Summary Herbicide resistant weeds are a major impediment to Australian grain production and 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). An important factor in many HWSC systems is the proportion of weed seed exiting the harvester in the chaff fraction, with chaff carts, chaff tramlining, chaff lining and the Harrington seed destructor (HSD) only targeting this fraction. Therefore, this study was aimed at determining the proportion of annual ryegrass seed collected by harvester that subsequently exits in the chaff fraction under commercial harvest conditions. Dyed annual ryegrass or oat seed was introduced into the front of harvesters during the 2014 and 2015 harvests and these seed were then recovered from collected harvest residues. Five harvesters at separate locations were evaluated in 2014 with the proportion of introduced annual ryegrass seed collected in the chaff portion ranging from 27.9% and 69.6% (mean 47.1%) while between 1.2% to 9.2% (mean 3.7%) of seed was found in the grain portion. The proportion of oat seed recovered was 43.7% in the grain and 4.0% in the chaff. In 2015 using a single harvester at one location setup for maximum HWSC efficacy less than 5% of annual ryegrass seed was found in the straw fraction. It was determined that increasing harvester speed did not influence the proportion of annual ryegrass seed in the straw portion but did increase the proportion of wheat seed exiting in this fraction from 0.2% to 5.0%. This research shows that harvester set up and operation is important in the efficiency of HWSC as well as harvest efficiency.

Keywords Herbicide resistance, HWSC.

INTRODUCTION

A great proportion, if not most, of the crops across the cereal growing regions of south-eastern Australia contain populations of herbicide resistant annual ryegrass (*Lolium rigidum* Gaudin) and many of these populations are resistant to multiple herbicide modes of action (Broster *et al.* 2011, Boutsalis *et al.* 2012, Broster *et al.* 2013). As herbicides are the dominant weed control method the risk of herbicide resistance evolution is high posing a significant threat to the remaining effective herbicides. This has resulted in both farmers and researchers trying to reduce this reliance on herbicides by investigating alternate methods of weed control.

An increasingly popular alternative to herbicides is the suite of HWSC systems. These include narrow windrow burning, chaff lining, chaff tramlining, chaff carts and the Harrington seed destructor (HSD) (Walsh *et al.* 2013). HWSC targets weed species with a potential weakness, in that they retain a large portion of their seed at maturity (Walsh and Powles 2014). As such, while harvest can be a major factor in spreading weed seeds across a paddock, (Blanco-Moreno *et al.* 2004) it can also be utilised to reduce seed bank inputs.

An important factor in many HWSC systems (e.g. chaff carts, chaff lining and HSD) is that they only target the proportion of weed seed exiting the harvester in the chaff fraction. Therefore, this study was aimed at determining the proportion of annual ryegrass seed collected by the harvester that subsequently exits in the grain, straw and chaff fractions under commercial harvest conditions.

MATERIALS AND METHODS

2014 Harvest In 2014 sampling was undertaken in wheat crops on five different farms in southern New South Wales in December. The farmer's harvester (Sites 1 and 3 John Deere 9660 STS; Site 2 New Holland CR9080; Site 4 John Deere CTS; Site 5 Case 8120) was used with the machine set up as for the rest of that paddock, however harvester speeds and settings were not recorded. The harvest height at all sites was 15 cm, the optimal height for HWSC.

The plots were 20 m long and the width of the harvester front. Either 10,000 ryegrass or 500 Winteroo oat seeds that had been dyed (to differentiate from native seeds) were introduced into the front elevator of the harvester for the full length of the plots. Winteroo oats were chosen as the wild oat proxy as they were a similar size to wild oat seed and they accepted the dye better than the wild oats. Large bags were used to catch the grain and chaff portions of the harvested material. To minimize interference with air flow the chaff collection bags were made from shade cloth.

2015 Harvest In 2015 sampling was undertaken at a single location using one harvester fitted with an integrated HSD operating at the different ground speeds (4, 6 and 8 km h^{-1}) but with no other setting changes. Plot length was 50 m but sampling only took place in the last 20 m with the first 30 m used to obtain the required ground speed. As in 2014, 10,000 dyed ryegrass seeds were introduced into the front elevator of the harvester over the 20 m sampling length.

The straw fraction of the harvested material was caught on shade cloth which was rolled out as the harvester moved. To reduce the amount of material to be processed for annual ryegrass seed recovery much of the larger sized straw material was raked out of the collected sample in the field.

Sample processing Chaff and straw samples were processed in the laboratory to allow the collection and subsequent counting of annual ryegrass seed. In 2014 the amount of ryegrass seed in the uncollected straw fraction was determined as the difference between that introduced into the harvester and that found in the grain and chaff portions. In 2015 any wheat seed found in the straw portion was also collected and the percentage of grain loss calculated for each plot.

Crop yield was calculated from dry matter cuts in 2014 and from a yield monitor in 2015.

RESULTS

2014 Harvest The mean wheat yield at the five sites was 2.72 t ha^{-1} (1.85–3.67) with a mean harvest index of 37.3% (32.6–44.3). The straw fraction was 42.7% (30.5–52.3) of the total dry matter production and the chaff fraction the remaining 20% (13.3–25.2).

There were differences between harvesters in the proportion of annual ryegrass and oat seed recovered in the grain (difference between minimum and maximum – annual ryegrass 775%; oats 185%) and chaff (annual ryegrass 250%; oats 675%) fractions of the harvested material (Figure 1). There was no significant correlation between wheat yield or harvest index and the proportion of ryegrass or oat seed recovered in either the grain or chaff fraction (data not shown).

On average 3.7% (1.2–9.2) of annual ryegrass seed was recovered in the grain fraction and 47.1% (27.9–69.6) in the chaff fraction. The harvester with the highest level of ryegrass seed in the grain fraction (Site 1) had the lowest percentage in the chaff fraction. Conversely, the site with the highest percentage of ryegrass seed in the chaff fraction (Site 4) had the lowest percentage of seed recovered in the grain fraction, although the amount of seed recovered from the grain fraction was no different to that of the other sites (except Site 1).

On average 43.7% (32.3–60.6) of the oat seed was recovered in the grain fraction and 4.0% (1.5–10.2) in the chaff fraction. With the exception of Site 1, similar to the ryegrass, the sites with a low percentage of oat seed recovered in one fraction (grain or chaff) had a higher percentage of seed recovered in the other fraction (Figure 2).

A significant ($r = 0.874$; $P < 0.05$) positive correlation was recorded between the percentage of ryegrass and oat seed found in the chaff portion but none of the other correlations (grain:grain, chaff:grain or grain:chaff) were significant

2015 Harvest The mean crop yield in 2015 was 2.45 t ha^{-1}. There was a significant difference in crop yield for the three harvest speeds with a lower yield ($P < 0.01$; lsd = 0.26) recorded at 6 km h^{-1} (2.16 t ha^{-1}) compared with both 4 km h^{-1} and 8 km h^{-1} (2.67 and 2.54 t ha^{-1} respectively).

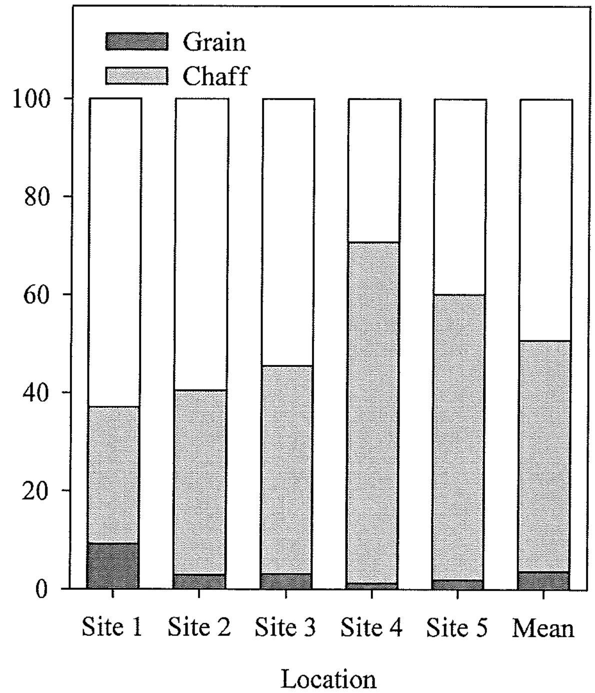

Figure 1. Differences between harvesters in 2014 for the amount of ryegrass seed found in grain ($P < 0.001$; lsd = 2.54) and chaff ($P < 0.001$; lsd = 16.3) fractions, the remainder of the seed was assumed to be in the straw fraction.

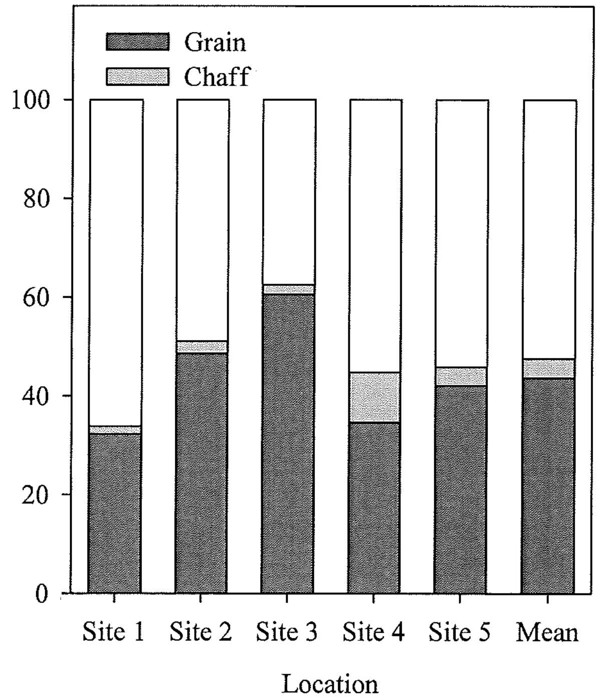

Figure 2. Differences between harvesters in 2014 for the amount of oat seed found in grain ($P < 0.001$; lsd = 6.27) and chaff ($P < 0.001$; lsd = 3.76) fractions, the remainder of the seed was assumed to be in the straw fraction.

bags used to capture the chaff portion interfering with air flow through the harvesters it is considered unlikely that this would affect nearly 50% of the introduced seed especially as large amounts of chaff were still being captured in these bags.

Harvester operation is of vital importance in maximizing the efficiency of HWSC systems, especially if the system chosen is one that focuses only the chaff fraction e.g. HSD, chaff carts, chaff lining or chaff tramlining. However, the differences between annual ryegrass and oat seed show that the most effective harvester operation for HWSC may also be species dependent (Figures 1 and 2).

When the settings are optimal for wheat, as was the case in 2015, the harvest speed was shown not to influence the amount of ryegrass seed present in the straw fraction (Figure 3). Increasing the harvester speed did result in increased grain loss (in the straw) especially when the harvester was operating at full capacity, in this case 8 km h^{-1}.

Those systems that target only the chaff fraction (e.g. HSD and chaff carts) also remove less nutrients (none for the HSD) than narrow windrow burning, a system which captures both the chaff and straw fractions of the harvested material. Narrow windrow burning is often the system chosen when farmers commence using a HWSC system due to its low setup cost. This is, however, offset by the increased labour component when burning the windrows.

Overall 3.38% of the ryegrass seed introduced into the harvester was recovered with no difference between the three harvest speeds ($P > 0.05$) (Figure 3a).

However, increasing the harvest speed from 6 to 8 km h^{-1} resulted in a significant increase in the amount of wheat seed found in the straw fraction, from 6.2 kg ha^{-1} (0.98%) to 127.4 kg ha^{-1} (5.03%) ($P < 0.001$; lsd = 37.04), there was no difference between 4 and 6 km h^{-1} in the percentage of wheat seed found (Figure 3b).

DISCUSSION

The harvester used in 2015 was set-up to maximize the efficiency of the attached IHSD. This is shown by the low percentage (3.4%) of ryegrass recovered in the non-targeted straw fraction, compared to the predicted average level of 49.2% (introduced minus grain and chaff) from the previous year. While part of this difference may have been due to the shade cloth

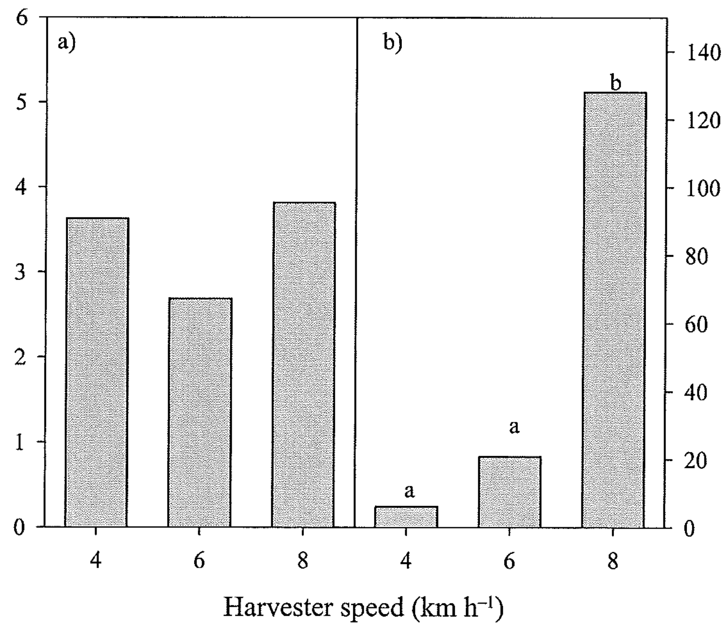

Figure 3. Percentage of annual ryegrass seed (a) and amount of wheat seed (kg ha^{-1}) (b) recovered from straw fraction of harvested material at three harvest speeds in 2015.

ACKNOWLEDGMENTS

This work was funded by a Grains Research and Development Grant (UWA00146). The authors would like to acknowledge the assistance of both casual staff and students from Charles Sturt University who assisted in the collection and processing of the samples. This work would not have occurred without the cooperation of several growers (Des Mason, Mark Kreutzberger, Andrew Harding, Ian Mason, Roy Hamilton and David Humphris) who generously made available their crops and harvesters for this research.

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