# Influence of annual ryegrass seed retention height on harvest weed seed control (HWSC) and harvest efficiency

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**Summary** HWSC is an Australian innovation where systems have been invented to specifically target the weed seed bearing chaff fraction during crop harvest. This approach to weed control is a response to escalating frequencies of herbicide resistant crop weeds that was developed because there is the opportunity to target the high seed retention levels of these weeds at crop maturity. However, seed retention is not complete and weed seeds are frequently retained at lower heights than crop seed heads. The aim of this study was to examine the seed retention height of annual ryegrass through the canopy of wheat crops at maturity. During the 2013 harvest period annual ryegrass and wheat plant material was collected at five heights (0, 10, 20, 30, and 40 cm) each within four 1.0 $m^2$ quadrats in 25 wheat fields across the WA wheatbelt. On average 66% of annual ryegrass seed was retained above a 10 cm harvest height. However, a harvest height aimed at grain collection only (30 cm) would have reduced annual ryegrass seed collection and HWSC potential to 40%. The major proportion of wheat biomass (66%) occurs above 30 cm however, reducing harvest height from 30 to 10 cm would mean the collection of an additional 14% of the total biomass production. Thus, operational cost of harvesting lower for HWSC is the processing of just an additional 14% of crop biomass. This will impact to some extent on the speed of harvest but in contrast the gains from the adoption and use of HWSC are substantial.

**Keywords** Herbicide resistance, harvest height.

## INTRODUCTION

Seed retention at maturity has been identified as a weed control target for the problematic annual weed species of Australian crop production systems. The major weeds, *Lolium rigidum* Gaudin (annual ryegrass), *Raphanus raphanistrum* L. (wild radish), *Bromus* spp. (brome grass) and *Avena* spp. (wild oats) retain significant proportions of total seed production, above a low harvest height (15 cm) at wheat crop maturity (Walsh and Powles 2014). During wheat harvest, the seed of these weeds are collected and processed and then exit the harvester, predominantly in the chaff fraction, where they are evenly redistributed across the paddock. Preventing inputs to the weed seedbank has been a focus for weed control for many years and therefore, harvest is now recognized as a weed control opportunity. Subsequently, HWSC systems have been developed specifically to target weed seeds during commercial wheat crop harvest to prevent inputs to the seed bank (Walsh *et al.* 2013).

Approaches used to target weed-seed bearing chaff include: collection and subsequent burning (chaff cart), concentration in a narrow windrow with straw residues for subsequent burning (narrow windrow burning), collection in bales along with straw residues (bale direct system) and mechanical destruction during harvest (Harrington seed destructor). When implemented effectively, these systems all deliver similarly high levels of weed seed destruction (>85%). Therefore, growers can choose an HWSC system to suit their farming operation.

The developed HWSC systems effect weed control by targeting the weed seed bearing chaff fraction and when implemented correctly are all similarly effective. The overall efficacy of these systems then is reliant on the proportion of total seed production that is collected during the harvest operation. The height and distribution of weed seed through the crop canopy at maturity impacts on the efficacy of HWSC. Thus the aim of this study was to establish the distribution through the canopy of mature wheat crops of retained annual ryegrass seed at widely dispersed WA wheatbelt locations.

## MATERIALS AND METHODS

At the start of the 2013 harvest, (Nov.–Dec.) wheat crops at 25 locations across the WA wheatbelt were sampled to establish the height of annual ryegrass seed retention at crop maturity. Sampling was conducted within the first one to two weeks past crop maturity. In each wheat crop a 1.0 $m^2$ quadrat was place around annual ryegrass plants, these along with the surrounding wheat plants were then sampled at five heights commencing at 40 cm above the soil surface and then at 10 cm intervals to the soil surface. The soil surface within quadrat area was swept with a brush to collect any seed, seed heads and plant material that had fallen from wheat and annual ryegrass plants. Four quadrat samples were collected at each location. Before processing, the collected plant samples were oven dried at 70°C for 48 hours and then weighed. Any wheat heads present at each sample height were threshed and weighed to determine crop yield and proportion of yield at each sampling height. Annual 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 annual ryegrass seed collected above each of the harvest heights was calculated for each site.

## RESULTS

Wheat crop sampling at 10 cm intervals from 40 cm downwards identified a uniform distribution of retained annual ryegrass seed through the wheat crop canopy at harvest (Figure 1). The 40 cm sampling height resulted in the collection of 24% of total seed production. Each successive 10 cm decrease in sampling height realised the collection of approximately 15% additional retained seed.

With the major proportion of total wheat biomass (61%) located above the 40 cm sampling height there were only reduced amounts of biomass collected at lower 10 cm sampling increments. As was observed for annual ryegrass seed distribution there were consistent proportions of wheat biomass collected at each of the 10 cm sampling intervals below 40 cm. However, in contrast to annual ryegrass seed retention only 8% of total biomass was collected at each of the 10 cm sampling increments. Therefore, at the 10 cm height the cumulatively collected proportion of wheat biomass was just 24% more than biomass collected at 40 cm.

Incremental sampling identified an average harvest height of 30 cm that would likely have been used to harvest the sampled wheat crops in 2013. Wheat grain was almost entirely located in the upper canopy (i.e. above 30 cm). Although on average 91% of wheat

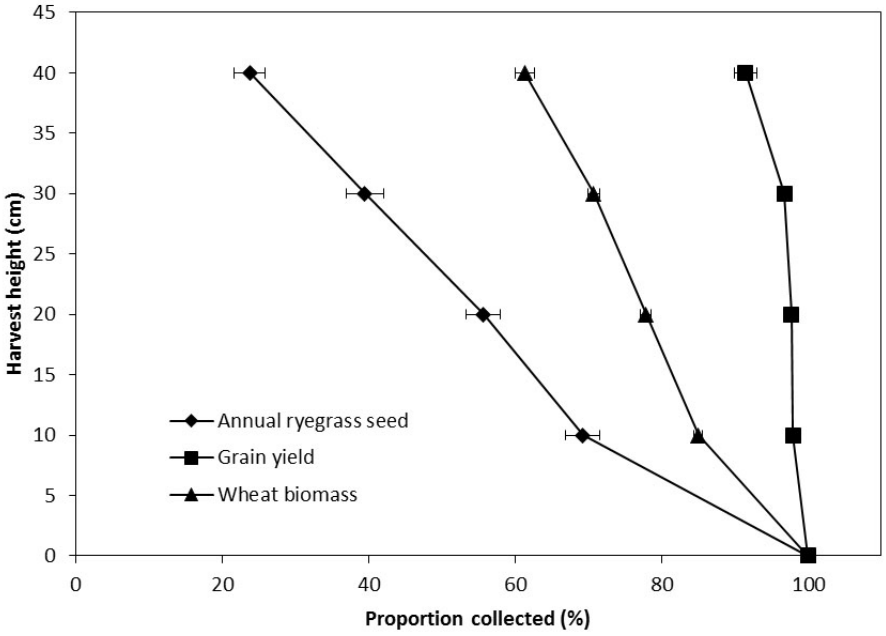


**Figure 1.** The cumulative proportion of annual ryegrass seed, wheat biomass and wheat grain collected at decreasing harvest heights.

grain was collected at the 40 cm sampling height, an additional 6% of yield was collected at the 30 cm height. There was no grain collected at the 10 or 20 cm sampling heights. However, there was some head and seed loss that prevented the entire grain production from being collected.

High average seed retention levels were recorded for annual ryegrass present in wheat crops across the WA wheatbelt during the initial stages of the 2013 harvest. In annual ryegrass infested areas of wheat crops at 25 locations across the WA wheatbelt there was an average of 66% of total annual ryegrass seed production retained above a low 10 cm harvest height (Table 1). Although, there was large variation around this mean seed retention (35–89) the median of 69 indicates that the majority sites had higher than average seed retention levels.

Annual ryegrass seed production levels clearly highlighted the seedbank replenishment/establishment potential for annual ryegrass plants surviving to maturity. The mean plant density for the sampled areas was 9 plants $m^{-2}$ with a seed production of 218 seed $plant^{-1}$. This would potentially result in a seedbank contribution of 2008 seed $m^{-2}$, more than sufficient for the establishment or continuation of an annual ryegrass infestation (Table 1).

**Table 1.** Annual ryegrass plant density, seed production and seed retention at wheat crop maturity at 25 locations across the WA wheatbelt in 2013. Numbers in brackets are the standard errors of the mean of four replicates.

| Location | Plant density (plants $m^{-2}$) | Seed Production (seed $m^{-2}$) | Seed retention >10 cm (%) |
|---|---|---|---|
| Mullewa | 16 (5.3) | 3287 (1134) | 56 (6.4) |
| Kulin | 20 (0.9) | 3527 (924) | 80 (4.9) |
| Eradu | 23 (0.1) | 4865 (1160) | 50 (13) |
| Gibson | 4 (1.3) | 346 (83) | 46 (13.9) |
| Bruce Rock | 6 (0.7) | 577 (193) | 84 (3.1) |
| Irwin | 3 (1.0) | 1091 (628) | 67 (8.2) |
| York | 7 (0.5) | 2366 (678) | 50 (3.3) |
| Wagin | 4 (0.6) | 951 (191) | 71 (6.0) |
| Pingelly | 4 (0.6) | 879 (184) | 78 (7.8) |
| Darkan | 9 (0.7) | 2147 (713) | 68 (6.6) |
| Hyden | 4 (1.2) | 1136 (222) | 75 (7.7) |
| Holt Rock | 7 (0.1) | 494 (156) | 85 (8.2) |
| Latham | 14 (6) | 3941 (1080) | 70 (8.7) |
| Muradup | 6 (0.8) | 1188 (511) | 64 (2.7) |
| Yarawindah | 3 (0.4) | 926 (367) | 69 (6.7) |
| Corrigin | 3 (0.4) | 429 (120) | 35 (3.8) |
| Tenindewa | 3 (0.4) | 817 (162) | 80 (3.1) |
| Koorda | 16 (3.4) | 1467 (494) | 78 (12.5) |
| Mingenew | 4 (1) | 798 (234) | 57 (13) |
| Callingiri | 35 (3.4) | 4144 (709) | 89 (2.7) |
| Coorow | 6 (1.5) | 983 (271) | 36 (19) |
| Scadden | 5 (1.3) | 487 (128) | 59 (4.6) |
| Wyalkatchem | 4.3 (1.4) | 2206 (321) | 60 (14.6) |
| Merredin | 3.8 (0.2) | 1872 (890) | 81 (4.7) |
| Kojonup | 34.7 (2.8) | 6177 (977) | 72 (4.0) |
| **Average** | **9.2 (0.9)** | **2008 (218)** | **66 (2.5)** |

## DISCUSSION

Across 25 WA wheat crops in 2013 66% of annual ryegrass seed production would have been collected at a 10 cm harvest height. Additionally it was determined that annual ryegrass seed was found to be retained uniformly through the wheat crop canopy profile, therefore any increase in harvest height consistently reduced the amount of seed collected. Cross-sectional sampling down through the crop canopy determined a uniform distribution of retained annual ryegrass such that every 10 cm cross section contained 15% of annual ryegrass seed production. Thus every 1 cm increase in harvest height would have resulted in a 1.5% reduction in annual ryegrass seed collection. Therefore, a 30 cm harvest height as identified as optimal for grain only collection in 2013 would have resulted in just 39% annual ryegrass seed collection.

With the majority of wheat crop biomass located above 30 cm then lowering harvest height does not substantially increase the amount of crop biomass that needs to be processed during harvest. Similar findings have been reported for wheat crops in NSW and Victoria (Broster *et al.* 2015). A barrier to the adoption and effective use of HWSC systems has been the perception that lower harvest heights result in the collection of excessive amounts of crop biomass.

Across the 25 wheat crops sampled in this study 66% of total biomass was located above 30 cm wheat only harvest height. Reducing this height to 10 cm resulted in just 14% additional biomass being collected.

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