ASSESSMENT OF THE RATE OF WEED SEED DECAY IN CHAFF-LINING SYSTEMS OF SOUTH AUSTRALIA

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TAKE HOME MESSAGES

- Investigation of weed seedbank decline in nine chaff-lining systems of South Australia demonstrated that growers are achieving high concentration of weed seeds and crop residue at harvest.
- Assessment of the viable weed seed fraction after crop harvest suggests that large residual annual ryegrass, brome grass and Indian hedge mustard seedbanks have been established in cropping field because these species did not decay over the summer-autumn period in chaff-lines.
- Evaluation of chaff-tramlining systems showed that annual ryegrass seedbank decline is independent of chaff-line configuration and chaff density.
- The stability in the weed seedbanks in chaff-lines were consistent with the dry conditions over the summer-autumn period.
- Growers should be cautious of the magnitude of viable weed seeds in chaff-lines before the cropping season and expect variability in the effectiveness of this tactic between seasons.

Why do the research?

Failure to control annual weed species that persist through cropping phases facilitates replenishment/establishment of weed seedbanks. Consequently, this maintains weed interference in subsequent years of crop production. Harvest weed seed control (HWSC) has been widely adopted in Australia since its inception over three decades ago to prevent redistribution of weed seeds across cropping fields during commercial harvesting operations (Walsh et al. 2017). Implementation of HWSC obstructs fresh seedbank inputs by subjecting the weed seed bearing chaff fraction to a treatment, such as combustion (narrow windrow burning), mechanical pulverisation (impact mills), decomposition (chaff-lining) and removal (chaff cart). Chaff-lining has been readily adopted by growers because of the low cost of modifying a harvester to confine the chaff fraction into a narrow row between stubble, or onto dedicated wheel tracks in controlled traffic farming systems (chaff-tramlining). There is only a small amount of literature examining seedbank decline of important Australian weed species in chaff-lines, however a common conjecture is that a mulching effect is created by a combination of physical and chemical influences (Walsh et al. 2018). Field observations suggest that in the absence of seed decay, control failures of annual weed species and volunteer crop plants may be exacerbated. Therefore, growers urgently need information that substantiates the implications of chaff-lining to weed seedbanks.

How was it done?

Field sites were established at nine different locations with varying rainfall in SA (Figure 1). Sites were selected on the premise of dense annual ryegrass or brome grass infestations. Random sampling was performed at each site across four chaff-lines along a horizontal transect in areas of uniform weed density. Sub-samples were made at 0.5 m intervals so that 1.5 m of the chaff-line was collected. A vacuum was used to ensure complete capture of all weed seeds on the soil surface. In systems with a chaff-deck configuration, both chaff rows were sampled to alleviate distribution bias of the chaff fraction. Sub-samples were bulked and stored in an air-conditioned laboratory. Data on harvest height, and chaff-line depth and width was also obtained. This sampling strategy was repeated at random intervals from December to April.

Chaff was separated from the soil using a sieve and both components were weighed. A 25% sub-sample by mass was taken from each of the components and bulked together. The chaff-line material was spread between a 20 mm base and top layer of potting mix (coco-peat) in germination trays in the first week of May. The trays were then watered close to field capacity. Supplementary irrigation was supplied to trays if there was ten consecutive days without rainfall to ensure the potting mix was moist. Weed seedlings were routinely counted and removed to determine weed seed decay over the summer-autumn period. The data collection ceased in mid-September when no new seedlings emerged after two consecutive counts.

Figure 1. The geographical distribution of six chaff-lining (■) and three chaff-tramlining (▲) sites across the three rainfall zones of the major cropping regions of South Australia, which include the Yorke Peninsula (high), Mid-North (medium) and Eyre Peninsula (low).

There were no consistent trends that demonstrated the susceptibility of annual ryegrass to decay in chaff-lines (Table 2). There was a reduction in annual ryegrass seedbank at three sites (3, 5 and 9), but a repeated measures Analysis of Variance (ANOVA) showed these were non-significant (P=0.361) and associated with the natural variability that exists at these sites. Large variation in the annual ryegrass and brome grass seedbank was identified between sites (P<0.001), but these seedbanks behaved similarly in wheat chaff-lines of different agro-ecological zones. The magnitude of annual ryegrass and brome grass seed capture (93-29831 seeds/m^2) demonstrates that HWSC tactics could have an important role in reducing weed seedbanks (Table 1, T able 2). Further research is needed to determine the implications that the large residual annual ryegrass (597-18492 seeds/m^2) and brome grass (219-23612 seeds/m^2) seedbank in chaff-lines will have to crop production.

Indian hedge mustard control failures at Site 7 (Minnipa, South Australia) enabled investigation of the fate of its seeds in wheat chaff-lines. There was a 43% reduction in the Indian hedge mustard seedbank 125 days after harvest. However, there was no difference (P=0.322) between the initial and final Indian Hedge mustard seedbank (Figure 2). Our previous work in GRDC project UA00156 has shown that Indian hedge mustard has a low level of innate dormancy and readily germinates under favourable soil moisture conditions. The high organic carbon levels of chaff are likely to support microbial biomass, which has been associated with seed decay in statice (Kleemann and Gill 2018). While fatal germination, seedling recruitment and seed decay may contribute to some degradation of the Indian hedge mustard seedbank, spatial variability of this species within the field appears most important to the observed declining trend in the seedbank.

Table 1. Temporal changes in the brome grass seedbank concentrated in wheat chaff-lines at three different sites in South Australia, at Pinery (Sites 3 and 4) and Wharminda (Site 9).

Time of sampling	Mean brome grass density (seeds/m^2)		
	Site		
	3	4	9
1	14410	240	2363
2	18803	191	2072
3	26049	646	1963
4	23612	219	*

*Not sampled

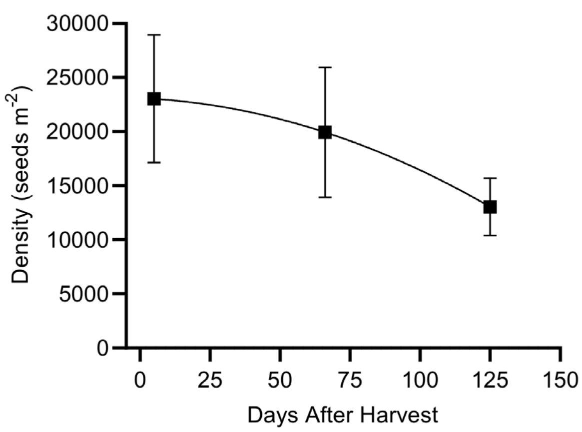

Figure 2. The temporal decline in the Indian hedge mustard seedbank in wheat chaff-lines after crop harvest at Minnipa, South Australia. Each point is the mean of four replicates and vertical bars are the standard error of the mean.

Table 2. Tolerance of the annual ryegrass seedbank to chaff-lining in wheat at nine different sites across the major cropping regions of South Australia; Yorke Peninsula (Sites 1-2), Mid-North (Sites 3-6) and the Eyre Peninsula (Sites 7-9).

Time of sampling	Mean Annual ryegrass density (seeds/m^2)								
	Site								
	1	2	3	4	5	6	7	8	9
1	93	5325	1343	3301	22678	8444	25287	513	7134
2	450	11176	982	5467	16969	11464	29831	2399	5443
3	597	7503	1409	7718	26686	12177	29244	1352	4657
4	*	*	1301	4829	18492	8657	*	2143	*

*Not sampled

Chaff density

Chaff-density was calculated by assessing the chaff-line dimensions during sampling and processing. Similar patterns of seedbank decline were observed across the nine different sites in response to chaff density. Variability in the annual ryegrass and brome grass seedbank was not associated with increasing density of chaff-lines at sites across the Yorke Peninsula, Mid-North and Eyre Peninsula (Figure 3). Despite visual differences in chaff-deposition onto dedicated tramlines, a two-sample t-test showed that these were non-significant (P=0.448) and did not contribute to weed seed decay (Figure 3A). The levels of seed decay documented in the present study are consistent with findings in northern Australia by Ruttledge et al. (2018) in GRDC project UQ00084. While weed seed fate was not affected by chaff density, Ruttledge et al. (2018) reported suppression (15-35%) of annual ryegrass emergence in response to burial in chaff-lines under glasshouse conditions.

Climatic implications

Exhaustion of weed seedbanks in chaff-lines occurs through seedling recruitment, seed decay, or a combination of these two factors. Climatic factors are intrinsically linked to regulating the germination behaviour of weed species, while sensitivity of soil microorganisms to temperature and moisture gradients determines rates of substrate depletion.

A HOBO® logger was placed at the bottom of chaff-lines at each site to collect data at hourly intervals on relative humidity, temperature and the number of dew events. The median temperature of chaff-lines ranged from 15.3-28.7°C (Figure 4), while there were no differences detected between sites (P=0.056). Despite the low C: N ratio of wheat residues, the concentration of organic matter in a chaff-line is likely to promote microbial activity.

Microorganisms are known to excrete enzymes which have an important role in mediating weed seed decay. The temperatures recorded in this study are likely to have an increased rate at which these enzymes function, resulting in rapid decay of weed seeds. The stability of the annual ryegrass and brome grass seedbank in chaff-lines demonstrates that low soil moisture may have restricted soil microorganism populations. Even though the median number of dew events at Maitland (11) was more (P=0.011) than other sites (Figure 4), there was no reduction in the annual ryegrass seedbank (Table 2).

Rainfall data was sourced over the duration of the study from the nearest Bureau of Meteorology automatic weather station for all sites. Rainfall across the different regions was well-below average and represented 20-23% of the long-term mean (Figure 5). Intermittent, full hydration of annual ryegrass seeds associated with the summer-autumn rain is known to accelerate dormancy release by altering the seed composition of abscisic acid and gibberellins (Goggin et al. 2012).

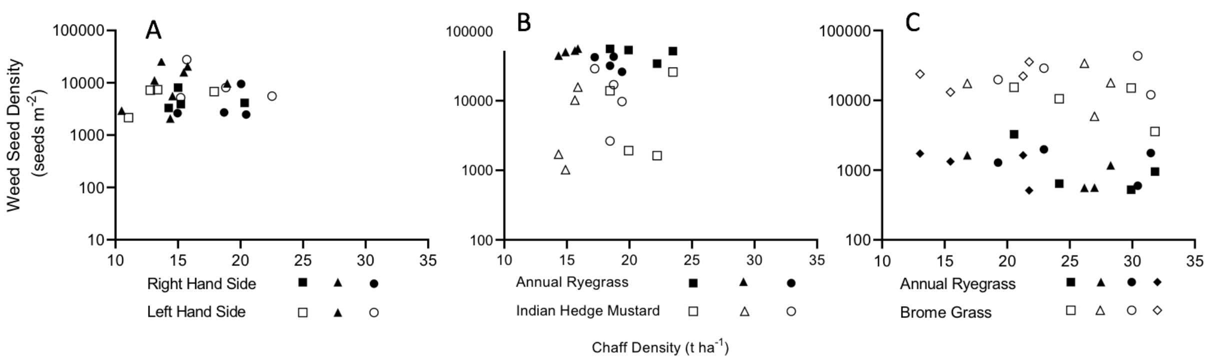

Figure 3.The relationship between seed fate and chaff density for different weed species under chaff-tramlining (A) and chaff-lining systems (B and C) at Maitland, Minnipa and Pinery, South Australia, respectively. Samples were collected at regular intervals over the summer-autumn period: T1 ■ ; T2 ▲; T3 ●; and T4 ◆.

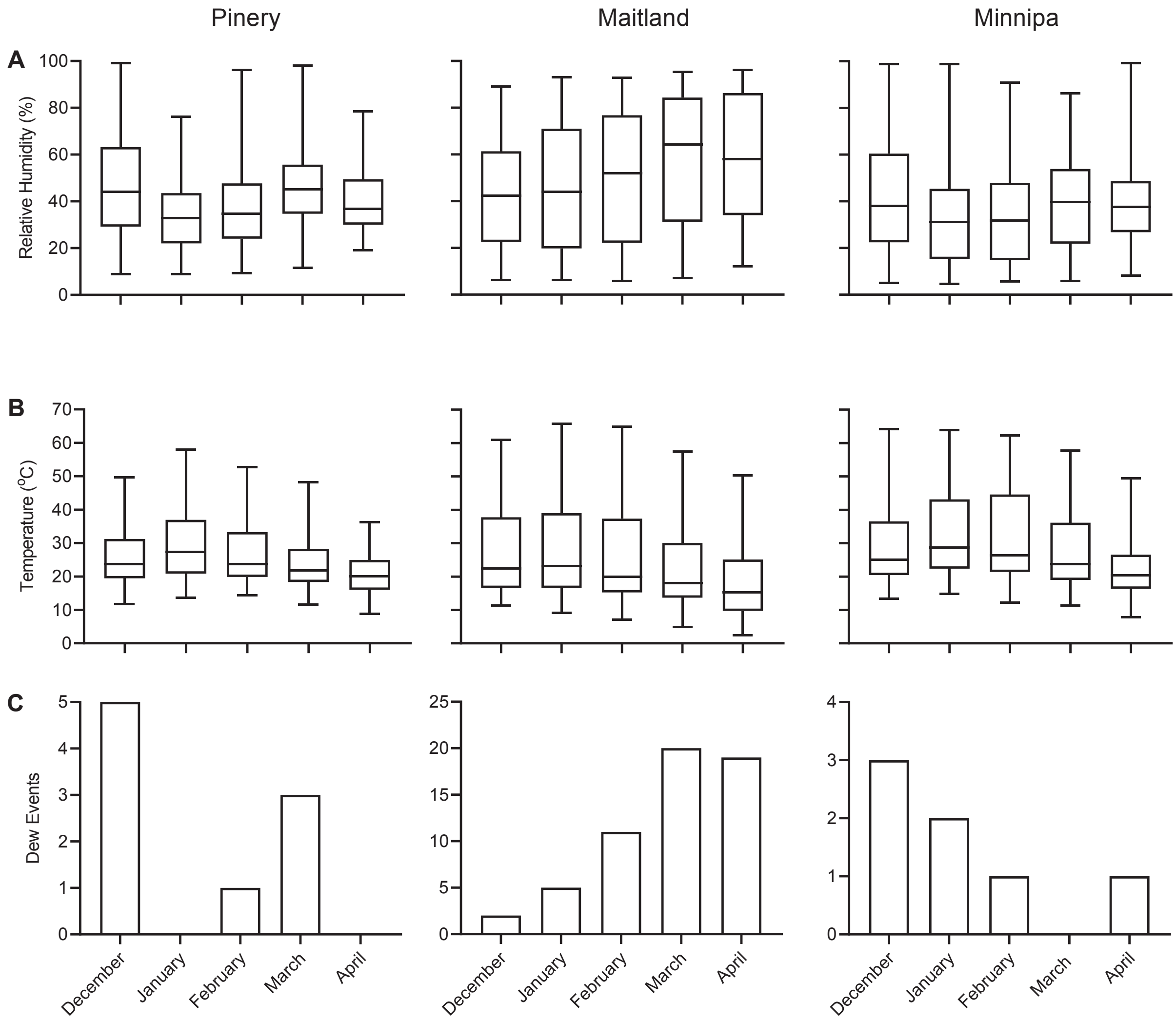

Figure 4. Observations from the Yorke Peninsula (Maitland), Mid-North (Pinery) and Eyre Peninsula (Minnipa) on relative humidity (A), temperature (B) and the number of dew events (C) over the sampling period. This data was collected at hourly intervals using a HOBO® logger that was placed on the soil surface beneath the chaff-line.

Rainfall deficiencies over the summer-autumn period may provide some explanation for weed seedbank stability in chaff-lines. Instead, the small rainfall events that were reported (Figure 5) are likely to have initiated transient hydration, which is known to reduce the time between imbibition and germination in annual ryegrass (Goggin et al. 2012). The temperature of the maternal environment in the year of annual ryegrass seed development has also been found to strongly influence seed dormancy (Steadman et al. 2004).

Brome grass seeds are photosensitive and preferentially germinate with burial, but populations in South Australia have been shown to exhibit a vernalisation requirement to release dormancy (Kleemann and Gill 2013). It is possible that the seed water content of annual ryegrass and brome grass varied in response to changes in relative humidity across the different sites (Figure 4). However, a previous Australian study showed dormancy release rates in annual ryegrass were not modified by natural fluctuations in humidity (Steadman et al. 2004). The proportion of the annual ryegrass and brome grass seedbank that is depleted in chaff-lines by fatal germination or seedling recruitment is difficult to predict because of their complex seed dormancy characteristics.

Investigation of weed seedbank decline in nine chaff-lining systems of South Australia demonstrated that growers are achieving high concentration of weed seeds and crop residue at harvest. Assessment of the viable weed seed fraction after crop harvest suggests that large residual annual ryegrass, brome grass and Indian hedge mustard seedbanks have been established in cropping fields because these species did not decay over the summer-autumn period in chaff-lines. Evaluation of chaff-tramlining systems showed that annual ryegrass seedbank decline is independent of chaff-line configuration and chaff density. The stability in the weed seedbanks in chaff-lines were consistent with the dry conditions over the summer-autumn period; however, infrequent rainfall over this period is not unusual in South Australia. Therefore, growers should be cautious of the magnitude of viable weed seeds in chaff-lines before the cropping season and expect variability in the effectiveness of this tactic between seasons. Implementation of targeted control of these chaff-lines may be necessary to mitigate seedbank replenishment; however, care should be taken to prevent lateral dispersal of weed seeds by vectors, such as livestock and machinery.

Acknowledgments

The research undertaken as part of this project is made possible by the significant contributions of the growers through both trial cooperation, Jerel Fromm, Ian Noble and Ed Hunt on EP, and the support of the GRDC in project UA00156. Thank you to Ian Richter, Katrina Brands, Bradley Hutchings and Steve Jeffs (SARDI) for their technical input to the EP samplings.

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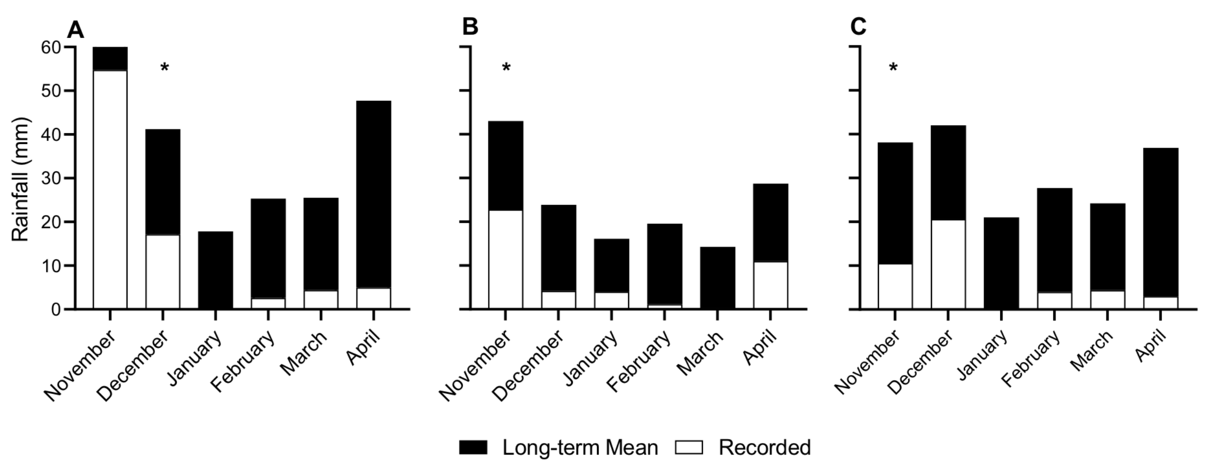

Figure 5. The long-term mean and recorded monthly rainfall for the chaff-lining field sites at Maitland (A), Pinery (B) and Minnipa (C), South Australia, following harvest (*).