Emergence pattern and seedbank decline of emerging weeds in the field

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Key messages

- Higher levels of seed dormancy were found for cropped populations of barley grass. This would allow it to germinate and establish after pre-sowing management, and will make selective control difficult in a cereal crop.
- There was no clear effect of site management (cropped vs. non-cropped) on the germination behaviour of brome grass, however more than 25% of the seedbank can potentially carry-over from one year to the next.
- Changes in the germination behaviour of barley grass appeared to be associated with a higher carry-over component of the seedbank. Wireweed can exhibit high levels of seed dormancy and consequently seedbank persistence is likely to be long (>5 years).

Aims

Changes in farming systems, farm management practices and climate are resulting in a changing weed spectrum. Several weed species that tended to be mainly weeds of pastures (e.g. barley grass) have now become significant weeds of crops. These weeds are increasing costs and reducing yields (Llewellyn et al 2016). To manage these emerging weeds effectively, growers are seeking information on their behaviour, especially seed bank persistence. At present, information on weed seed bank biology is not available for many of these weed species. Even where research is available on seed bank biology, much of this previous research was undertaken prior to the intensification of cropping and introduction of no-till systems. It is likely that the behaviour of weed species would have changed considerably over the last 20-30 years. A national GRDC project (UA00156) aims to quantify the rate of decline of weed seed-banks under field conditions. The aim of this four-year trial is to understand the seed bank longevity (persistence) of emerging weed species in the absence of seed production in Western Australian cropping systems.

Method

A large initial seedbank (1000 seeds m^{-2}) of barley grass, brome grass, doublegee, windmill grass and wireweed was established on the deep yellow sand at the Wongan Hills Research Station, Department Primary Industries and Regional Development (DPIRD) to investigate the rate of seedbank depletion under a wheat rotation from 2016 to 2019. Seeds of two populations of each weed species, one from a cropped and the other from non-cropped area were collected in the spring/summer of 2015/2016,

A site with few weeds was selected and prior to the study existing weeds were controlled by applying non-selective herbicide (Roundup® PowerMAX 1.5 L/ha + 2,4-D ester 500 mL/ha + Garlon® 60 mL/ha) on 8 February 2016, cultivation (autumn tickle) on 7 April 2016, non-selective herbicide (Roundup® PowerMAX 2 L/ha + Hammer® 25 mL/ha) on 14 April 2016 and a second cultivation on 9 May 2016. Prior to crop planting large seedbanks (1000 seeds m^{-2}) of each population were established in replicated micro-plots ($1m^2$) within each main-plot (5m x 2m) with 4m buffer between replications. Clearfield wheat at 80 kg/ha was sown on 26 May in 2016 (yr1) and 25 May in 2017 (yr2) using a knife point and press wheel system on 22 cm row spacing's. Fertiliser MacroPro Plus at 80 kg/ha was banded below the seed, with 50 kg/ha of additional N (Flexi N) applied at the tillering stage of wheat. Post-emergent Intervix® (750 mL/ha) was applied at the tillering stage of wheat to control wild radish and annual ryegrass

Weed seedlings were counted after each rainfall event and removed to prevent seed set and partial replenishment of the seedbank. Since all weeds were counted and removed at the seedling stage, crop growth and yield were uniform. As a result, yield was not assessed at harvest. Emergence of the target weed species was monitored during summer following each rainfall event, but none of the species emerged over summer. Other summer weed species were sprayed with non-selective herbicide where necessary.

Table 1: Monthly mean rainfall in 2016 and 2017 relative to the long-term average (1907 to 2017) for Wongan Hills (weather station 008137.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	91	0	93	56	42	64	69	51	25	15	2	6
2017	63	49	21	21	20	13	47	65	38	18	2	7
Long-term average	15	16	21	23	52	70	69	52	30	20	12	10

Design and analyses

The trial was conducted in a randomised complete block design with four replications. Data on weed emergence were tested using ANOVA.

Results

Weed seedling emergence pattern in 2016 season

There were large differences in the seedling emergence pattern between the weed species. Despite brome grass and doublegee emergence being recorded on several occasions (9 cohorts), most seedling emergence occurred within 50 days of sowing (Figure 1). In contrast, barley grass showed very slow seedling recruitment with the most significant cohort occurring 40 days after sowing. Barley grass is known to have a vernalisation requirement to overcome seed dormancy (Fleet and Gill 2012). Seedling emergence of wireweed was relatively low (<50 plants/m^2), but also delayed by about 50 days.

Emergence pattern in 2017 season

Similar to year1, maximum seedling emergence was again higher for brome grass and barley grass, however, wireweed showed greater final establishment than doublegee (Figure 1). Not surprisingly, maximum seedling recruitment for brome and barley grass was significantly lower in yr2 with a large proportion of the seedbank exhausted within yr1. Barley grass showed faster rate of emergence in yr2, with seeds primed for germination following a longer period of after-ripening in the field. Wireweed establishment was similar between years, with only a few plants required to seed set and replenish the seedbank.

There was no emergence of windmill grass in 2016 or 2017.

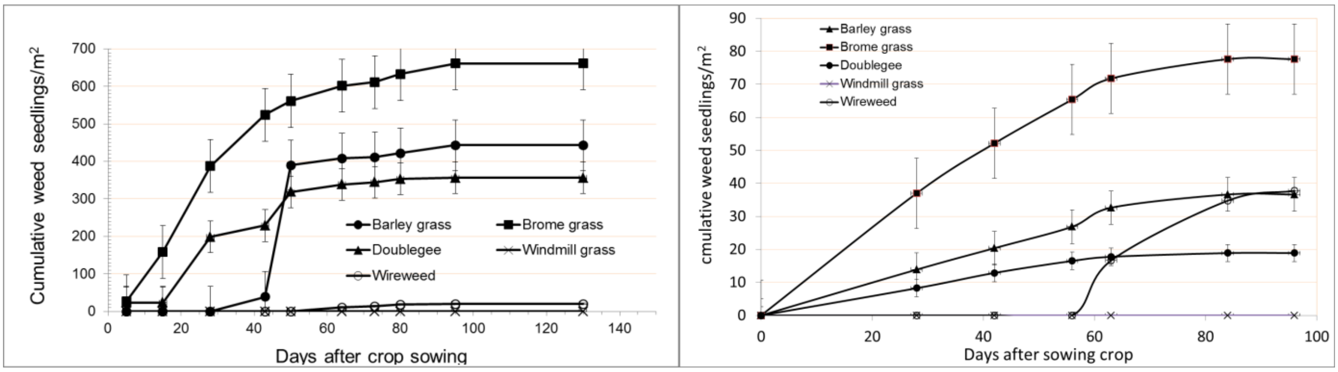

Figure 1 Cumulative seedling emergence of five weed species in a wheat crop, recorded after each rainfall event during the 2016 (left) and 2017 (right) seasons at Wongan Hills, Western Australia.

Emergence of all weed species was delayed by 28 days in 2017 due to dry conditions in May and June (Table 1). However, crop emergence took place at 5 to 7 days after sowing as the crop seed was placed at a depth where there was adequate soil moisture. Unlike 2016, emergence of barley grass was not delayed compared to brome grass or doublegee, but emergence in wireweed was delayed by four weeks compared to the other species (Figure 1, right).

Effect of populations on emergence

Of the weed species investigated, barley grass and wireweed showed clear and large differences in seedling emergence patterns between populations from different site management (cropped vs. non-cropped; Table 2). Pairwise comparisons revealed delayed start to seedling emergence for cropping populations of both barley grass and wireweed in comparison to populations from adjacent non-cropped areas. Seedling emergence for cropping populations was considerably lower in y1 for barley grass (13%) and wireweed (12%) relative to non-cropped populations. This result is in support of previous research (Fleet and Gill, 2012 – barley grass) that also showed that barley grass populations from cropped situations were much slower to emerge than those from non-cropped habitats.

Furthermore, the authors concluded that grower management had selected for increased seed dormancy in cropped populations, allowing these weeds to thwart early control, and become more troublesome weeds across southern Australia.

In yr2 seedling recruitment was higher for cropping populations of barley grass, where a higher proportion of the seedbank had carried over from yr1 to 2. Several studies have reported that weed species that exhibit longer seed dormancy tend to have more persistent seedbanks showing greater seed carry-over from one season to the next. Higher seedling recruitment was also observed for cropping populations of brome grass and doublegee in yr2.

Table 2 Effect of populations collected from the cropping and non-cropping area on the emergence pattern of five weeds in a wheat crop at Wongan Hills in 2016 and 2017.

Weed species	Emergence (plants/m^2) 2016		Emergence (plants/m^2) 2017	
	Crop	Non-crop	Crop	Non-crop
Barley grass	102	785	42	2
Brome grass	702	610	85	17
Doublegee	471	241	19	6
Wireweed	5	35	2	17
Windmill grass	0	0	0	0
P-value	<.001		<.001	
Lsd(5%)	85.26		3.45	

Decline in weed seed bank

Averaged over both populations, at the end of two seasons, the cumulative percent emergence of seedlings for each species was 48% (11% crop and 85% non-crop) of the seedbank for barley grass (carry-over >50%),

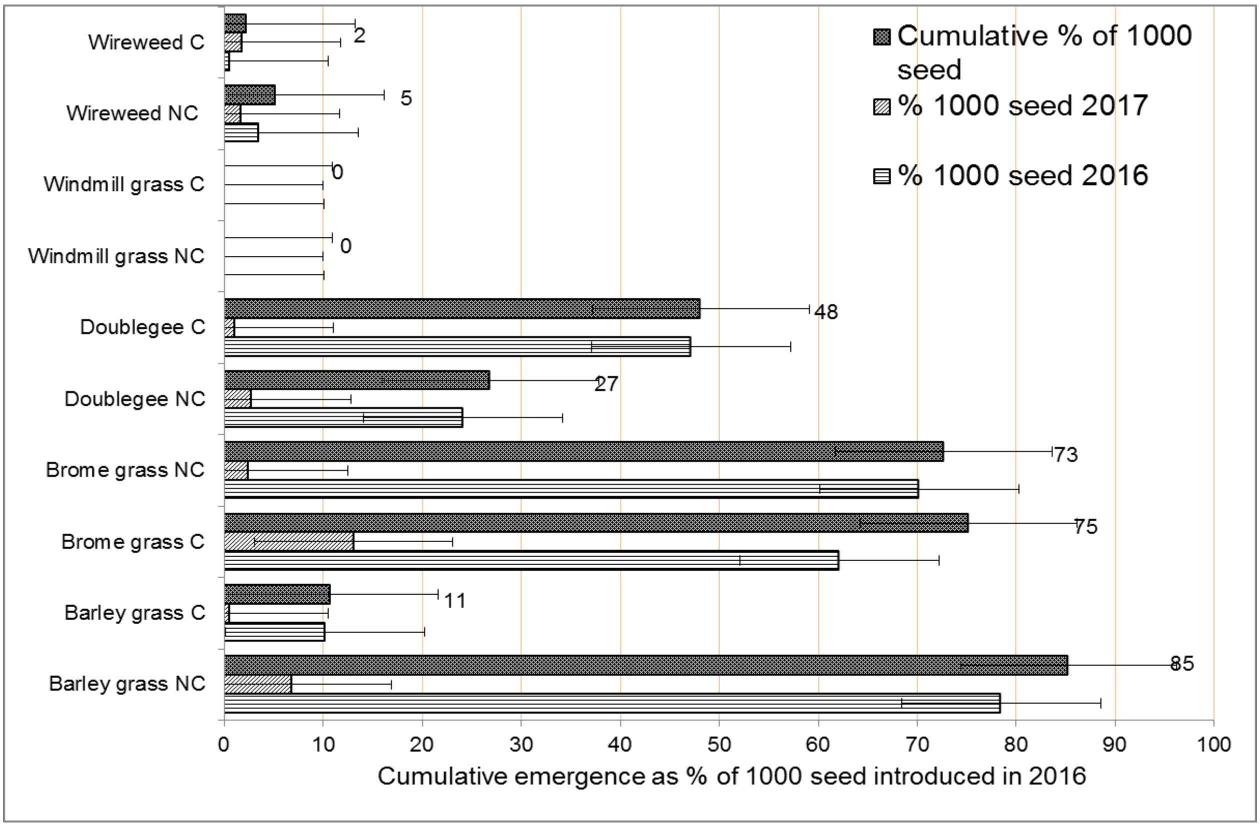

Figure 2 Seasonal and total percent seedling emergence of five weed species in a wheat crop in 2016 and 2017, out of a total seed bank of 1000 seed/m^2 at Wongan Hills, Western Australia. The horizontal bars indicate standard errors of four means.

74% for brome grass (carry-over >20%), 37% for doublegee (carry-over >60%), and 6% for wireweed (carry-over >90%) (Figure 2). Seedling emergence for brome grass, barley grass and doublegee was much greater in 2016 than 2017. Although the total emergence of wireweed seedlings was only 6% of the seedbank, twice as many seedlings emerged in 2017 compared to 2016.

Conclusion

Seedling emergence was protracted for most of the weed species investigated in this study, and this would make in-crop management more difficult. Fortunately, however, these late cohorts are less competitive and produce fewer seeds.

The unusual delay in the emergence of barley grass relative to the crop suggests that some WA populations of barley grass may have developed increased seed dormancy similar to populations found in South Australia (Fleet et al 2012, Gill et al 2013, Cook 2017). Barley grass seed showed no protracted dormancy in populations in 1999 (Peltzer and Matson, 2002; Herbiguide 2017) with most seedlings emerging prior to crop sowing being more easily controlled with pre-sowing herbicides. Increased seed dormancy in barley grass would allow it to thwart early season weed control tactics, making selective control in cereals more difficult. Furthermore, Borger and Hashem (2018) showed that these late germinations, whilst producing fewer seeds, had a shorter growth habit and greater potential to escape harvest weed seed control (HWSC). Seedling recruitment was also lower for these more dormant populations, and consequently could contribute to the development of a more persistent seedbank. This would have implications for the duration of management required to exhaust the seedbank to low levels, and growers would need to consider planning crop rotations that provide consecutive years (2-3 years) of effective control of these weeds.

Key words

See bank persistence, seed dormancy, crop and no-crop populations, barley grass, brome grass, doublegee, windmill grass, wireweed.

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