What's the worst weed in Wongan Hills?

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Key messages

Brome grass seedling recruitment was higher than annual ryegrass recruitment in 2017, even though annual ryegrass had much higher seed set in 2016. As a result, brome grass had a greater impact on crop yield in 2017.

Barley grass, doublegee, wireweed and sowthistle had delayed emergence compared to the crop, leaving these species poorly competitive in 2016 and 2017.

Brome grass, barley grass, doublegee and sowthistle all shed their seed earlier than annual ryegrass. Harvesting as early as possible or swathing would be necessary to capture seeds from these species for harvest weed seed destruction.

Aims

Annual ryegrass is the worst weed in Australia, in terms of area infested, impact on crop yield and cost of herbicide resistance management (Llewellyn *et al.*, 2016). However, changes to the agronomic system and environment have ensured that other winter weed species are increasingly detrimental. For example, brome grass species are now the fourth most problematic weed in Australia (Llewellyn *et al.*, 2016). Further, many common summer weed species in Western Australia have little information available on biology and ecology. A trial at Wongan Hills aimed to investigate the biology of eleven weed species, including Afghan melon, annual ryegrass, barley grass, button grass, caltrop, doublegee, great brome grass, roly poly, sowthistle, windmill grass and wireweed. In this paper, we compare the emergence, growth, seed production and shedding time of annual ryegrass, great brome grass, barley grass, doublegee, sowthistle and wireweed, growing in a wheat crop.

Method

A field trial was run at Department of Primary Industries and Regional Development (DPIRD) Wongan Hills Research Station in 2016 and 2017, on yellow sand. In 2016, a site with few weeds was selected and prior to the trial, existing weeds were cleared using non-selective herbicide and cultivation (Table 1). Prior to seeding Mace wheat, the plots were sown with one of 11 different weed species; Afghan melon, annual ryegrass, barley grass, great brome grass, button grass, caltrop, doublegee, roly poly, sowthistle, windmill grass and wireweed. The trial also included weed free control plots. The trial was established as a randomised block design with two dimensional balance (i.e. 12 weed species comparisons and 3 replications were blocked in two directions, Coombes, 2008).

No in-crop herbicides were applied during the 2016 growing season, to determine the maximum population growth rate of each weed species (i.e. to simulate how they would grow assuming they had herbicide resistance). Any additional weeds in the trial were removed by hand, and other pests were controlled as required to ensure healthy crop growth. All non-target summer weeds (i.e. those weed species not deliberately sown to establish the trial) were removed by hand in the summer of 2016/2017. In 2017, the trial was resown to Mace wheat. While a non-selective herbicide was applied, low summer and autumn rainfall at the site ensured that winter weeds did not germinate prior to seeding the crop. Again, non-target weeds were removed by hand and other crop pests were controlled where necessary.

Table 1: Date and agronomic details for each operation involved in running the trial in 2016 and 2017.

Date	Operation
8/2/2016	Non-selective herbicide: Roundup® PowerMAX 1.5 L/ha + 2,4-D ester 500 mL/ha + Garlon® 60 mL/ha.
7/4/2016	Cultivation: to 5 cm (autumn tickle to stimulate germination and emergence).
14/4/2016	Non-selective herbicide: Roundup® PowerMAX 2 L/ha + Hammer® 25 mL/ha.
9/5/2016	Cultivation: to 5 cm to kill remaining weeds.
26/5/2016	Sow weeds: manually spread 100 seeds/m^2 of Afghan melon, annual ryegrass, barley grass, great brome grass, button grass, caltrop, doublegee, roly poly, sowthistle, windmill grass or wireweed over each plot. A weed free control treatment was also included.
26/5/2016	Seeding: Mace wheat (knife points with press wheels), at 22 cm crop row spacing, 3-4 cm depth. MacroPro Plus® at 80 kg/ha, approximately 3 cm below the seed.

16/8/2016	Pest control: Prosaro® 150 mL/ha + Alpha-Scud® 250 mL/ha + 1% wetter
1/12/2016	Harvest: at a height of 15 cm.
25/5/2017	Non-selective herbicide: Spray.Seed® 2.5 L/ha.
25/5/2017	Seeding: As for 2016.
17/7/2017	Fertiliser: 50 L/ha Flexi-N®
12/9/2017	Pest control: Dimethoate® 400 mL/ha
23/11/2017	Harvest: at a height of 15 cm.

Each year, ten weeds per plot were marked with pegs to monitor growth and seed production of individual plants in the initial weed cohort. For all weed species, later cohorts emerged during the season, but the ten marked plants were the earliest weeds to appear in each plot, as these early weeds are the largest/most competitive in crop. The seed heads of the marked weeds were bagged and checked every two weeks to monitor total seed production and time of shedding. Height of each seed head was also assessed. Weed density was assessed at multiple times during the season (time of assessment varied between weed species) from 50cm by 50cm quadrats. Weed density and seed production per plant were used to estimate weed seed production/m^2. This paper will discuss growth of the winter or winter/spring weeds; brome grass, barley grass, annual ryegrass, doublegee, sowthistle and wireweed.

Results

Emergence, survival and weed seed production

Emergence from the initial 100 seeds/m^2 in 2016 ranged from 11 plants/m^2 for wireweed to 668/m^2 for barley grass (Table 2). Seed production was greatest in annual ryegrass, followed by brome grass and sowthistle. However, plant density in 2017 was greatest for brome grass, followed by annual ryegrass. These two species had increased seed production in 2017 compared to 2016. Barley grass, sowthistle, doublegee and wireweed had similar or reduced plant density, and similar or reduced levels of seed production in 2017 compared to 2016. Note that wireweed seed production was very low in 2016, so the plants that emerged in 2017 must have resulted from some of the initial 100 seeds/m^2 in 2016 lying dormant between years.

Table 2: Average density and seed production of each weed species in the 2016 and 2017 growing season.

Species	2016		2017	
	Plant density (m^2)	Seed production (m^2)	Plant density (m^2)	Seed production (m^2)
Annual ryegrass	65	9366	203	29 496
Great brome grass	60	3484	349	29 129
Barley grass	68	889	42	884
Doublegee	55	336	7	*
Sowthistle	50	3207	8	2009
Wireweed	11	1	17	*

*Wireweed and doublegee continued to set seed after harvest 2017, and so final seed production data is not yet available.

In each year, the first cohort of great brome grass and annual ryegrass (i.e. the marked plants in each plot) emerged at the same time as the crop, and both of these species remained at a similar growth stage to the crop throughout the year. The marked plants in each plot had high survival rates during the growing season, with 97% survival of great brome grass and 100% survival of annual ryegrass until senescence prior to crop harvest. An example of the growth stages of great brome grass in 2017 is shown in Figure 1.

By comparison, the barley grass, doublegee, sowthistle and wireweed all had the initial cohort germinate after the crop was established. An example of the growth stages of barley grass in 2017 is shown in Figure 1. The initial 10 barley grass plants/plot emerged from June to September, and many plants died prior to seed set (Figure 1). All barley grass had naturally senesced by crop harvest, but some of the doublegee, sowthistle and wireweed plants were still green in November 2016 and 2017.

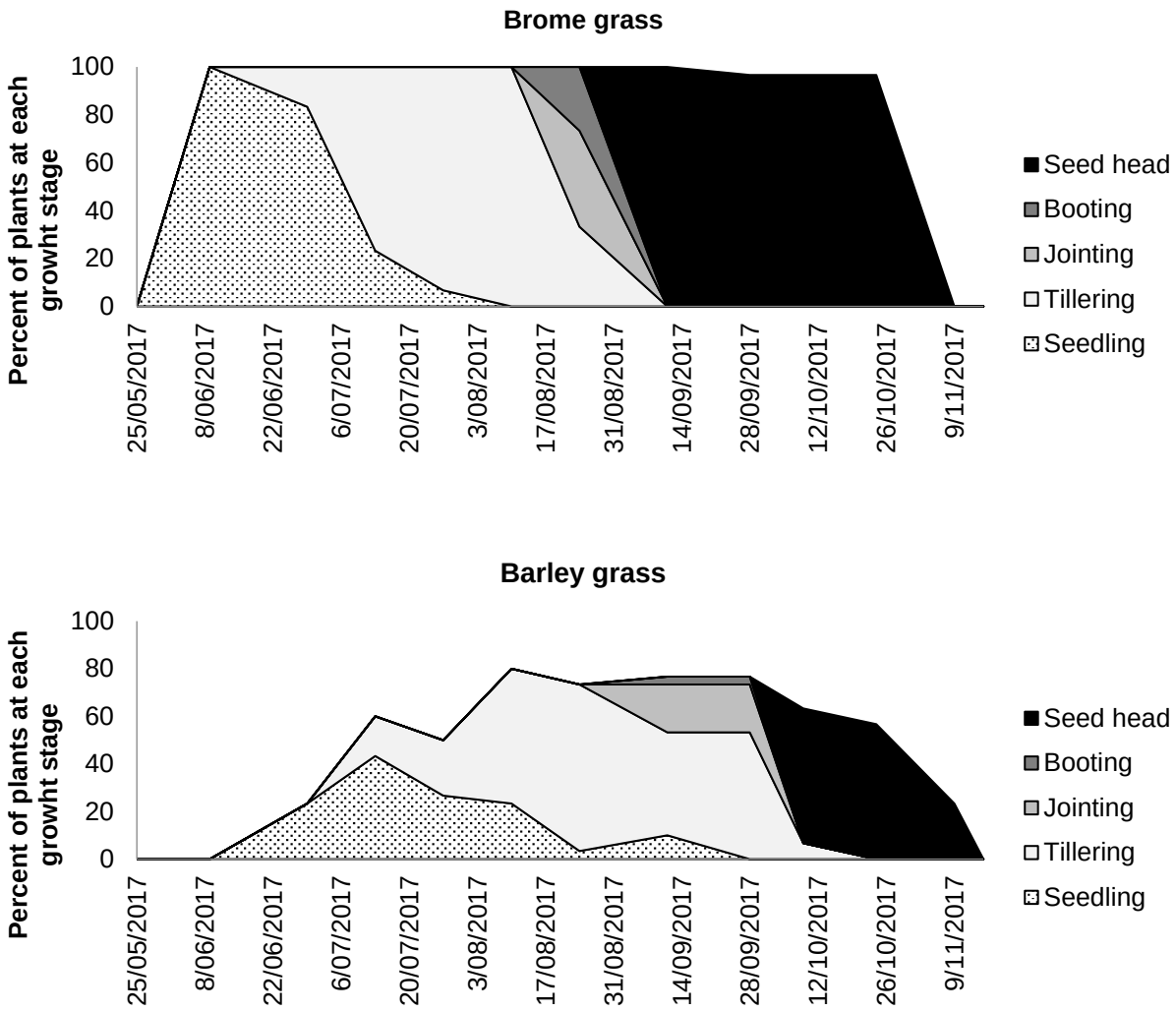

Figure 1: The percent of great brome grass and barley grass plants at each growth stage (seedling, tillering, jointing, booting and seed head) in a wheat crop during the 2017 season, from crop sowing (25/05/2017) to harvest (23/11/2017).

Weed seed shedding

In 2016 and 2017, the earliest possible harvest date occurred in mid-November (14/11/2016 and 9/11/2017, Table 3). In both years annual ryegrass retained most seed until crop harvest, with only 24% and 13% of seed lost prior to harvest in 2016 and 2017. All annual ryegrass seed heads were above harvest height. In mid-November (14/11/2016 and 15/11/2017), great brome grass had shed 64% of seed in 2016 and 70% of seed in 2017. However, in 2017, the crop was ready for harvest a week earlier (9/11/2017), when great brome grass had only shed 28% of seed. Great brome grass sheds rapidly over November, and in 2016, where harvest did not occur until December, 100% of seed was shed prior to harvest. All great brome grass seed heads formed above harvest height. Harvest needs to occur as early as possible to capture great brome grass seeds.

Barley grass started shedding seed in October, but retained 62% of seed at crop maturity in 2016 and 96% in 2017 (Table 3). However, in this particular trial, the barley grass was poorly competitive due to late emergence and the plants did not grow taller than 10-12 cm. Therefore, all seed heads were below the harvest height of 15 cm. As the barley grass plants had senesced, crop harvest caused sufficient disturbance to shed the remaining seed heads, but seeds were not captured by the harvester.

Sowthistle and doublegee plants both started shedding seed in October, in each year. Sowthistle shed 94% or 95% of seed prior to harvest in 2016 and 2017, and doublegee shedding 100% of seed prior to harvest. Note that the heavy spring rainfall in 2017 allowed many doublegee to remain green and continue growing throughout harvest, to set seed during summer (Bureau of Meteorology, 2017). Table 3 only includes doublegee seed from those plants that had senesced at harvest. Seed production from the plants that set seed after harvest has not yet been assessed. Most sowthistle plants were below harvest height, with less than 1% of the marked plants taller than 15 cm in 2016 and 2017. However, the harvest event caused sufficient disturbance that the remaining sowthistle seeds shed onto the ground. All doublegee plants were below harvest height. Wireweed set and shed seed after harvest, and plants were below harvest height.

Table 3: The cumulative percent of seed shed by each weed species from 7/10/2016 to 1/12/2016 and from 9/10/2017 to 23/11/2017. In 2016, the crop was harvested on 1/12/2016 but was ready for harvest on 14/11/2016. In 2017, the crop was harvested on 23/11/2017 but was ready for harvest on 9/11/2017. All species had 100% shedding at harvest as the harvester either caught seeds or caused sufficient disturbance that the seeds fell to the ground.

Species	Year	7/10/2016	24/10/2016	7/11/2016	14/11/2016	25/11/2016	1/12/2016
Annual ryegrass	2016	0	1	3	9	24	100
Great brome grass		0	0	1	64	100	
Barley grass		0	8	13	38	100	
Doublegee		0	63	82	82	100	
Sowthistle		0	27	32	87	95	100
Wireweed		0	0	0	0	0	0
Species		**9/10/2017**	**24/10/2017**	**9/11/2017**	**15/11/2017**	**23/11/2017**	
Annual ryegrass	2017	0	1	3	13	100	
Great brome grass		0	6	28	70	100	
Barley grass		0	4	4	8	100	
Doublegee*		25	25	100			
Sowthistle		0	0	72	94	100	
Wireweed		0	0	0	0	0	

* Doublegee in 2017 does not represent an entire data set. Seed shedding is for those plants that matured and set seed prior to harvest. Many plants shed seed after harvest, and this data is not included in the table.

Crop yield in 2016 and 2017

In 2016, weed density was low and none of the weed species had a significant impact on crop yield (Table 2, Table 4). In 2017, the great brome grass plots had lower yield than the plots with other weed species ($P<0.001$, Lsd: 407.6).

Table 4: Average yield of wheat in each year.

Species	2016 yield (kg/ha)	2017 yield (kg/ha)
Barley grass	4690	2062
Great brome grass	3933	1251
Doublegee	5121	2230
Annual ryegrass	3961	1867
Sowthistle	3856	2297
Wireweed	3604	1967
Weed free control	4008	1934

Conclusion

Great brome grass did not produce as many seeds as annual ryegrass in 2016, but still had higher seedling recruitment in 2017. While annual ryegrass has very high seed production, the seeds are small, with a very thin seed coat. We know that seed predation (by ants, mice etc.) of small seeds like annual ryegrass or sowthistle can be close to 100% over summer, whereas larger seeds like great brome grass are a less desirable food source (Spafford Jacob *et al.*, 2006). This seed predation is the most likely reason for the low recruitment of annual ryegrass compared to great brome grass in the 2017 season. As great brome grass germinates at the same time as the crop, it is highly competitive with wheat, as indicated by the reduced crop yield in 2017. Therefore, it is very important to control great brome grass through an integrated weed management program (Storrie, 2014). Harvest weed seed destruction may be an effective control measure for great brome grass. Walsh and Powles (2014) noted great brome grass seed retention of 77% at crop maturity, and Hashem *et al*. (2017) found 74% of great brome grass seed could be captured if harvest height was 10 cm. This is similar to the 72% seed retention in 2017 and much higher than the 36% retention in 2016 in the current study. It is clear that great brome grass seed retention at harvest varies between years, due to seasonal conditions and the time at which the crop reaches maturity. When using harvest weed seed destruction, harvest should be completed as soon as possible in those fields where great brome grass is a problem. Alternatively, swathing may be used to reduce weed seed shedding. Further research is required to determine the success of swathing or harvest weed seed destruction for great brome grass.

The barley grass used in this trial had delayed emergence, making it poorly competitive with the crop. While it is common for barley grass populations to develop delayed emergence to avoid non-selective herbicides, some populations emerge earlier and may compete more effectively with the crop than was found in this trial (Gill *et al.*, 2012). Barley grass retained seed more effectively than great brome grass and so harvest weed seed destruction may be effective on populations of barley grass with plants that grow taller than those plants in this trial.

Doublegee, sowthistle and wireweed also germinated well after the crop and were not highly competitive in this trial. Wireweed seed set was particularly low in 2016. These species are unlikely to be highly competitive in wheat crops, although further research is required in other locations and crops. Prior research has indicated that doublegee can

grow up into the crop canopy, particularly in short pulse crops, and can contaminate yield in some locations (Peltzer & Douglas, 2017). Sowthistle tends to be more common in the southern wheatbelt and may be more competitive in this region than in Wongan Hills (Borger *et al.*, 2018).

Key words

Bromus diandrus, *Hordeum leporium*, *Emex australis*, *Sonchus oleraceous*, *Polygonum aveculare*, *Lolium rigidum*.

Note that ® indicates Registered Trademark.

Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994.

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