

## How fast do the seedbanks of five annual cropping weeds deplete in the absence of weed seed input?

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**Summary** The seedbank longevity of five annual weed species, annual ryegrass, barley grass, wild radish, wild oat and wall fumitory was measured throughout the southwest land division of Western Australia. The effect of tillage on seedbank persistence was determined. After the break of each season, the number of germinated and emerged seedlings were counted approximately every six weeks then sprayed with Spray.Seed™. No seed set was allowed.

Barley grass did not persist in the soil while the seeds of the other species persisted in the soil for several years. The annual ryegrass seedbank declined at a rate of 70 to 80% per annum while wild oat declined by 80% in the first year but only 50% in the second. The wild radish and wall fumitory seedbanks decline rates varied enormously depending on the age of the seedbank and whether or not cultivation has taken place.

Tillage stimulated seedling emergence in annual ryegrass, wild oats, wall fumitory and wild radish but not in barley grass.

**Keywords** Seedbank persistence, emergence, tillage.

### INTRODUCTION

Two factors determine how many weeds will emerge. The first is the seed rain at the end of the season, and second, the proportion of this seed and the seed from previous seasons that can survive in the soil and subsequently germinate. The persistence of a weed seedbank depends on the proportion of seeds that either germinate or remain dormant (Buhler *et al.* 1998). The persistence of each weed seed population can be determined by measuring the time taken for the number of weed seeds in the soil to diminish to negligible levels and at the same time preventing new ones from entering.

Factors affecting weed seed germination and subsequent seedling emergence include light, soil conditions such as temperature and moisture, the soil's gaseous environment and nutrient status. Tillage can affect seed germination by redistributing the seed to a different profile in terms of moisture, temperature etc. or changing the amount of available light.

This study aimed to generate seedbank decay curves for major annual weeds in Western Australia across different soil types and rainfall regions. The

effect of tillage as a method to accelerate seedbank decline for these weeds was investigated.

### MATERIALS AND METHODS

The seedbank longevity of annual ryegrass (*Lolium rigidum* Gaud.), barley grass (*Hordeum leporinum* Link.), wild radish (*Raphanus raphanistrum* L.), wild oat (*Avena fatua* L.) and wall fumitory (*Fumaria muralis* Sond. ex Koch) was measured in a series of field trials throughout the southwest land division of Western Australia. The trials were situated on naturalised weed populations and were located in Mullewa (28.5°S, 115.5°E), Wongan Hills (30.8°S, 116.7°E), Beverley (32.1°S, 116.9°E), Katanning (33.7°S, 117.5°E) and Mount Barker (34.6°S, 117.6°E). The soil types of these trial sites ranged from deep sands, gravel loams to heavy red clays. Annual rainfalls ranged from 340 to 740 mm.

Each trial had two treatments (tilled to a depth of five cm each year or left uncultivated) in a complete randomised block design with four replicates. There were two extra control plots that were established at either end of the treatment area, separated from the controls by a 15 m buffer. The whole trial area was surrounded by a 20 m buffer. This was to prevent seed contamination from outside. Each treatment plot was counted approximately every 4–6 weeks for seedling emergence following the break of each season and then sprayed with paraquat plus diquat as Spray.Seed™ to kill each cohort. All plants in the treated plots were completely destroyed to prevent seed replenishment. The control plots were allowed to set seed each year and left *in situ* until the end of the experiment.

### RESULTS

The seedbank decline rate differed substantially between weed species. Barley grass seed possessed little or no dormancy and did not persist in the soil (Figure 1). Conversely, the seeds of Annual Ryegrass and Wild Oats persisted in the soil for several years. The pattern of seedbank persistence was consistent between the trial sites regardless of soil type or rainfall. Over 99% of the barley grass seedlings emerged from soil within two months of the break of the first season ( $P < 0.05$ ). The annual ryegrass seedbank declined at a rate between 72 and 78% per annum while wild oat

declined by 80% in the first year but only 61% in the second (Figure 1). The majority of annual ryegrass and wild oat emerged in the first two months after the break of each season.

Tillage stimulated seedling emergence in annual ryegrass, had a variable effect in wild oats but no effect on barley grass ( $P < 0.05$ ). Tillage only affected annual ryegrass in the first year (Figure 2).

The seedbank decline rate of wild radish varied considerably depending on tillage and the age of the seedbank. Wild radish emergence was stimulated by tillage in the second year at Mount Barker (Figure 3) and Wongan Hills ( $P < 0.05$ ). Tillage had no effect on wild radish emergence at two sites in Mullewa ( $P < 0.05$ ). The emergence of seedlings continued throughout the growing season.

Cultivation stimulated seedling emergence and increased the Wall Fumitory seedbank decline rate from negligible levels to between 50% and 65% (Figure 4). The stimulation effect of tillage occurred every year for three years.

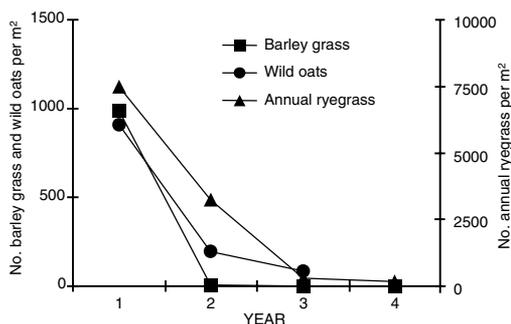
#### DISCUSSION

A dormant seed is defined as one that will not germinate under conditions normally favourable for seedling growth (Egley 1986). Different plant species have different types of dormancy and rely on different environmental or edaphic cues to break it.

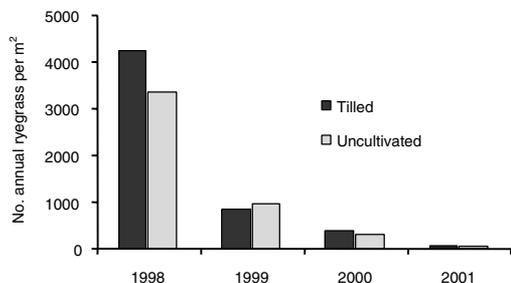
Barley grass possessed little or no long-term dormancy. The majority (over 99%) of the viable seeds in the seedbank germinated and emerged in the first few weeks after the autumn break following the year in which they were shed. Germination studies on five annual barley grass species, including *Hordeum leporinum*, concur with these findings (Popay 1981, Tucker 1989). If barley grass seedlings are controlled early in the season and not allowed to set seed then near eradication is possible. Tillage did not affect germination and subsequent seedling emergence of barley grass, in both this and an earlier study by Smith (1968).

Conversely, annual ryegrass demonstrated some level of dormancy and the seedbank persisted for several years. Tillage increased the emergence of annual ryegrass in the first year. Smith (1968) reported that covering the seed with soil increased germination. An annual ryegrass seed population has light and dark-dormancy after shedding and the dark dormant component can be as high as 10–20% (Gramshaw 1972). It is likely that tillage moves seeds from light to dark and vice-versa to allow the dormancy to break and germination to occur. This would account for the effect of tillage to occur only in the first year.

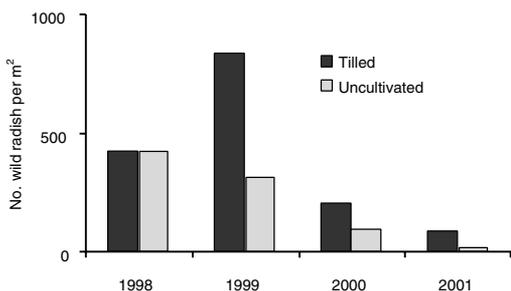
The wild oat seedbank also persisted for several years declining rapidly in the first year with the decline



**Figure 1.** The emergence of three annual grass weed species per annum from soil at Katanning and Beverley (mean of eight replicates). No seed set was allowed.

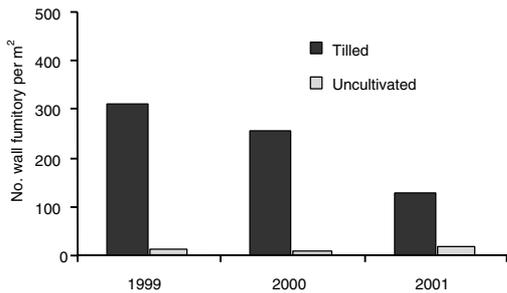


**Figure 2.** The number of annual ryegrass seedlings emerging per annum at Mount Barker, either tilled or left uncultivated (mean of six replicates). No seed set was allowed. (LSD ( $P = 0.05$ ): 1998 (833), 1999 (553), 2000 (217), 2001 (92)).



**Figure 3.** The number of wild radish seedlings emerging per annum at Mount Barker, either tilled or left uncultivated (mean of six replicates). No seed set was allowed. (LSD ( $P = 0.05$ ): 199 (196), 1999 (303), 2000 (68), 2001 (34)).

rate slowing in the second. Similarly, Nietschke (1997) noted that the greatest loss from the seedbank occurred in the first year for both *Avena fatua* and *A. ludoviciana* with a decline of about 80% slowing to around 30% in the second year. Wild oats have secondary and tertiary



**Figure 4.** The number of wall fumitory seedlings emerging per annum at Mount Barker, either tilled or left uncultivated (mean of six replicates). No seed set was allowed. (LSD ( $P=0.05$ ): 1999 (135), 2000 (169), 2001 (71)).

florets which tend to be more dormant than primary florets and are shed earlier from the inflorescence (Simpson 1992). The rapid seedbank depletion in the first year is due to the germination of seed from this primary floret (Geoff Barry, pers. comm). Emergence of seed from the secondary floret is consistent from year to year and would account for the slowing of seedbank depletion.

The effect of cultivation on wild oat emergence varied between trials in this study possibly due to the differing ages of the seedbanks studied. Previously, Peters (1991) and Medd (1990) have reported that cultivation increased emergence particularly from secondary seed in the first spring after burial. By the second year, seedling counts were similar from cultivated and non-cultivated soils.

The effect of tillage on the seedbank decline of wild radish varied between trial sites with some sites displaying a marked increase in seedling emergence in the second year. It is proposed that one year in the soil plus tillage can promote the wild radish pod to break down to allow the seed to germinate. The sites, which were affected by tillage, had seedbanks that were produced by seed rain the year before the trial began and consequently had seed of the same age. The two sites at Mullewa (where no effect of tillage was evident) had long-term seedbanks with wild radish seeds of different ages and in differing states of pod decay. Previous studies indicated that the wild radish pod had a delaying effect on emergence and germination did not occur until the seed coat was damaged (Young and Cousens 1999). Burial of seed enhanced dormancy breakdown (Cheam 1986).

Disturbance stimulated the emergence of wall fumitory in this trial and in investigations by Gertraud Norton (pers. comm.) who observed increased germination in six *Fumaria* species, including *F. muralis*.

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#### REFERENCES

- Buhler, D.D., Hartzler, R.G. and Forcella, F. (1998). Weed seed bank dynamics: Implications to weed management. *J. Crop Prod.* 1 (1), 145-168.
- Egley, G.H. (1986). Stimulation of weed seed germination in soil. *Rev. Weed Sci.* 2, 67-89
- Cheam, A.H. (1986). Seed production and seed dormancy in wild radish (*Raphanus raphanistrum* L.) and some possibilities for improving control. *Weed Res.* 26, 405-413.
- Gramshaw, D. (1972). Germination of annual ryegrass seeds (*Lolium rigidum* Gaud.) as influenced by temperature, light, storage environment, and age. *Aust. J. Agric. Res.* 23, 779-787.
- Medd, R.W. (1990). Seed bank dynamics of wild oat (*Avena fatua* L.) populations in wheat. Proc. 9th Aust. Weed Conf., Adelaide, Aug 6-10, 1990, 16-19.
- Niestchke, B.S. (1997). Integrated strategies for wild oat (*Avena* spp.) management in southern Australian farming systems. Faculty Agric. Uni. Adelaide; PhD Thesis.
- Peters, N.C.B. (1991). Seed dormance and seedling emergence studies in *Avena fatua* L. *Weed Res.* 31, 107-116.
- Popay, A.I. (1981). Germination of seeds of five annual species of barley grass. *J. Appl Ecol.* 18, 547-558.
- Simpson, G.M. (1992). Understanding seed dormancy in wild oats (*Avena fatua*) and its implications for control strategies. Proceedings 4th Int. Oat Conf. Wild Oats in World Agriculture, Adelaide 1992, 14-19.
- Smith, D.F. (1968). The growth of barley grass (*Hordeum leporinum*) in annual pasture. 1. Germination and establishment in comparison with other annual pasture species. *Aust. J. Exp. Agric. Animal Husb.* 4, 352-356.
- Tucker, S.T. (1989). Agro-ecological studies on diquat-paraquat resistant weed species. Faculty Agric. Uni. Adelaide, Ph.D. Thesis.
- Young, K. and Cousens, R. (1999). Factors affecting the germination and emergence of wild radish (*Raphanus raphanistrum* L.) and their effect of management options. Proc. 12th Aust. Weed Conf., Hobart, Sept. 12-16, 1999, 179-182.