Seed biology of brome grass weeds (*Bromus diandrus* and *B. hordeaceus*) and effects of land management

F. Dastgheib¹ and N. Poole²

IWM CONSULTANCY, 58 South Belt, Lincoln 7608, Canterbury, New Zealand

Foundation for Arable Research, P.O. Box 80, Lincoln 7640, Canterbury, New Zealand

Corresponding author: farhad@inet.net.nz

Abstract Aspects of seed biology of ripgut brome (*Bromus diandrus*) and soft brome (*B. hordeaceus*) were studied in relation to land management practices. Among the practices tested, burning stubble had a detrimental effect on seed survival. The majority of seeds close to the soil surface were charred or non-viable following a stubble fire. Overall, higher brome infestation was measured in no-tillage compared to minimum tillage or burning treatments. More than 80% of the seeds of both species emerged in the field within the first couple of months after planting, and full germination was achieved by spring. Seed burial at depths from 1 to 20 cm did not significantly affect germination but seedling establishment and vigour was reduced with seed depth. Implications of these results in management of brome grasses are discussed.

Keywords burning, cultivation, direct drill, cereals, grass weeds, minimum tillage, no tillage, ploughing, weed management.

INTRODUCTION

Brome grasses are very important weeds in arable crops and pastoral land. Although several overseas reports on their seed biology are available (Harradine 1986, Kleemann & Gill 2006), there is little information in New Zealand. Visits to cropping farms in Canterbury identified three species as the most common, namely ripgut brome (*Bromus diandrus*), soft brome (*B. hordeaceus*) and to a lesser extent prairie grass (*B. willdenowii*). These grasses pose a major challenge for arable farmers as there is no registered herbicide for their selective control in cereal crops. Dastgheib et al. (2003) identified a few herbicide mixtures that provide reasonable control of brome grasses in wheat as pre-emergence application. However, some barley cultivars have shown sensitivity

to these treatments (Rolston et al. 2003). A post-emergence herbicide (sulfosulfuron) is reported to provide selective control (Blackshaw & Hamman 1998) but this is not registered in New Zealand.

Sustainable control of problem weeds such as brome grasses should integrate chemical, physical and cultural components. Land management prior to sowing is an important part of such a programme. Therefore, an understanding of the response of weed seeds to land management practices is crucial in designing a sound integrated weed management strategy.

This research was undertaken to provide information about seed biology and behaviour of ripgut and soft brome that can be used in

formulating management programmes. Field trials were set up to assess the effects of different stale seedbed managements such as burning and tillage in winter barley on brome grass infestation. Laboratory tests were also conducted to explain the responses observed in the field with regard to seed biology. This paper presents results from three field experiments during the growing season of 2005-06, together with laboratory tests and observations made in 2009-10.

METHODS

Experiment 1: Effect of land management on brome grass density

A site with a history of natural brome grass infestation in Lyndhurst, Canterbury, was sown to winter barley cv. 'Tavern' at a rate of 100 kg/ha on 7 June 2005. There were four management treatments: (1) Burning: stubble was burnt on 9 March 2005 with no cultivation, (2) Early till: straw chopped by disc on 2 March 2005, (3) Late till: straw chopped by disc on 11 April 2005, and (4) No till: barley sown directly into chopped straw.

Plot size was 21 × 9 m with four replicates of each treatment arranged in a randomised complete block design. Brome grass counts and visual assessments on their infestation were made on 15 March and 29 April 2005, and numbers of seed heads were measured on 5 January 2006. The whole field including the trial site was sprayed with glyphosate at 360 g ai/ha on 16 March and 30 April 2005.

Experiment 2: Emergence pattern in the field during winter

A site with a very low weed population was prepared at the AgResearch farm, Lincoln. The experiment was set up in small plots of 3 × 1 m with four replicates arranged in a randomised complete block design. Seeds from seven populations of ripgut brome and two populations of soft brome were tested. Fifty seeds of each seed lot were sown by hand 10 mm deep in single 2.5-m long rows on 5 May 2005 and their emergence through the winter was followed by counting and removing emerged seedlings on 29 May, 29 July and 5 September 2005.

Experiment 3: Effect of burial depth on seed survival and germination

The site was the same as for Experiment 1. Pouches made of metal mesh containing 50 seeds of each brome species were buried in the soil at depths of 1, 5, 10 and 20 cm on 27 May 2005. These were removed at 1, 5 and 7 months after burial for assessing germination and seedling vigour. There were four replicates of each treatment (depth) at each harvest.

Laboratory tests

Germination tests were conducted by placing 25 sound seeds in moist paper rolls. These were maintained in light at either 10°C or 20°C constant temperature. For the dark treatment, paper rolls containing seeds were wrapped in black plastic sheets and inspected under a green light when required. Germination percentage was recorded at weekly intervals. Seeds were considered as germinated when both radicle and coleoptile were visible. Seeds that did not germinate after 3 weeks were declared dormant if firm or non-viable if they were soft and juicy. Viability of firm seeds was further examined by a standard tetrazolium test.

Seed collection and data analysis

Dry seed heads of both ripgut brome and soft brome were collected on 18 January 2005 from a barley field in Lyndhurst, and from two separate farms in Hororata on 15 February 2010. Seed heads were threshed by hand and clean seeds were stored at room temperature until they were used for the study.

All data were analysed through ANOVA using either Microsoft Excel or GenStat. Where F probability was significant, LSD ($P=0.05$) values were calculated for comparison of means. Percentage data were log transformed prior to analysis. The significance and ranking of treatment means were the same for original and transformed data so the original means are presented here.

RESULTS

Experiment 1: Effect of land management on brome grass density

The first assessment in March was made 6 days after burning stubble and 2 weeks after early minimum tillage but prior to late tillage operation. Significant reductions in the density of both brome grass species were found in burnt plots (Table 1). The density of ripgut brome was not significantly different between the three tillage treatments. At the same time in March, soft brome density was significantly lower in early tillage compared with late or no tillage treatments. April assessment showed no ripgut brome and fewer than two soft brome plants per m² in late minimum tillage plots while more seedlings of both species had emerged in the burnt plots. In the January assessment the highest numbers of brome grass seed heads were found in the no tillage plots with no difference between other treatments (Table 1).

Experiment 2: Emergence pattern in the field during winter

More than 73% of ripgut brome and 70% of soft brome seeds emerged 3 weeks after sowing (Table 2). By 8 weeks after sowing (end of July) cumulative emergence for ripgut and soft brome had reached 88 and 82%, respectively. More seedlings emerged through the season so that by September all seeds of both species had emerged.

Experiment 3: Effect of burial depth on seed survival and germination

At the first assessment in June (25 days after burial), no difference was found in germination of ripgut brome or soft brome seeds buried at different depths and most seeds germinated in their pouches (Table 3). Similar results were obtained in the other two assessments 5 and 7 months after burial. In the last assessment in January (7 months), these had grown to full size plants. Plants growing from 1 and 5-cm depths looked healthy and produced seed heads, while

Table 1 Brome grass density (plants/m², March and April 2005)¹ and seed head numbers/m² (January 2006)² in different treatments.

Treatment	Ripgut brome			Soft brome		
	March	April	January	March	April	January
Burning	4.5	12.0	0.1	6.0	45.7	0.1
Early till	44.8	40.2	0.5	29.8	35.0	0.1
Late till	36.5	0.0	0.5	148.9	1.7	0.1
No till	40.4	15.5	9.0	209.5	42.2	7.8
LSD (P=0.05)	28.96	21.50	3.7	93.56	ns	3.2

¹Mean of eight 0.1 m² quadrats per plot.

²Mean of six readings of 1 m² quadrats per plot.

Table 2 Percentage¹ of emerged seedlings during the winter.

Species	March	July	September
Ripgut brome	73.5 (1.38)	14.2 (1.65)	12.3 (1.19)
Soft brome	70.6 (3.20)	11.4 (3.35)	18.0 (0.15)

¹Mean of four replicates and either 7 (ripgut) or 2 (soft brome) populations; numbers in brackets are SEM.

Table 3 Percentage of brome grass seeds germinated in the field at different depths in June and observations in January.

Depth	Ripgut brome	Soft brome	January
1 cm	95.2	84.2	Almost all produced plants with seed heads
5 cm	98.1	97.7	Almost all produced plants with seed heads
10 cm	94.9	99.0	Almost all produced weak plants
20 cm	94.7	95.2	Almost all germinated but failed to produce plants
F test	ns	ns	

Table 4 Germination percentages of ripgut and soft brome seeds incubated at two temperature and light conditions.

Condition	Ripgut brome		Soft brome	
	7 days	14 days	7 days	14 days
10°C Light	13	96	9	98
10°C Dark	21	91	7	97
20°C Light	90	95	95	96
20°C Dark	92	92	96	97
LSD (P=0.05)	3.2	ns	3.6	ns

those from 10-cm depth were weak with no seed heads. Plants from 20-cm depth were etiolated and died before reaching the surface.

Optimum germination conditions

Seeds of both brome grass species harvested in February 2010 showed more than 90% germination after 7 days at 20°C regardless of light regime (Table 4). At the same time, germination was slow at 10°C ranging from 7% for soft brome to 21% for ripgut brome seeds, both kept in the dark. No significant effect from light was observed other than for ripgut brome seeds kept at 10°C after 7 days. By 14 days, most seeds had germinated (91–98%) showing no significant differences due to light and temperature.

DISCUSSION

For both species, burning stubble was very effective in killing seedlings and seeds. Almost 1 week after burning in March, only 4.5 ripgut brome and 6 soft brome seedlings/m² were measured, a reduction of 89% and 97%, respectively compared to the no-till treatment (Table 1). These seedlings were most likely saved

from burning either because they were sheltered within other plants or they were outside the path of fire. An old study by Floyd (1966) demonstrated the effect of burning plant debris on raising soil temperature. The author concluded that a hot slow fire would kill many weed seeds to greater depths, whereas a light flash fire that only raises the temperature of the top layer of the soil will have a restricted effect. At the experimental site in the present study, straw was relatively short. More effective burning can be expected with longer straw. Another factor in killing weed seeds by fire is the depth they are buried in the soil. An experiment at another site showed 88% of ripgut brome and 71% of soft brome seeds were killed by fire when placed at 1-mm depth as compared to only 18% of both species at 5-mm depth (F. Dastgheib, unpublished data).

The April assessment was made 18 days after the Late till operation. This treatment had killed emerged seedlings resulting in nil ripgut brome counts and only a few soft brome seedlings, which obviously escaped the disc (Table 1). In January, large reductions in both brome grass species were observed across all treatments. This

is to some extent due to glyphosate applications in March and especially in April and also due to drilling in June, which killed the emerged seedlings. In addition, strong competition from barley is expected to have killed many weeds. An assessment of the barley stand in October showed 92% cover in burnt plots, 96% in Till plots (both Early and Late), and only 50% cover in No till plots (data not presented). The weak competition from barley explains the significantly higher seed head numbers of both grasses in the No till treatment.

Laboratory experiments showed no effect of light on seed germination of the two brome grasses tested, while higher temperatures promoted earlier and faster germination rate but did not affect germination at 2 weeks (Table 4). Both positive and negative responses to light have been reported for brome grass species (Froud-Williams 1981; Hilton 1982; Cheam 1986; Simpson 1990), and some studies suggest different germination behaviour from different populations (Gill & Blacklow 1985; Kon & Blacklow 1988; Peters et al. 2000). The lack of response to light in laboratory tests supports the results presented in Table 3 showing high germination of both species when buried in the soil. Results from this study showing relatively short primary dormancy and short seed longevity are similar to other studies on *Bromus* species (Cheam 1987; Hilton 1987).

It appears that the brome grasses studied do not depend on light-induced germination, strong dormancy or seed longevity for survival but rely on other mechanisms such as prolific seed production and seed dispersal. A small proportion of seeds may exhibit short dormancy as evidenced by continuous emergence in the field (Table 2). These ensure seedling establishment at different planting dates and could be a source of contamination in spring. Observations in January showed many ripgut and soft brome plants in No till plots, some with green stems and leaves, suggesting they emerged late in the season and were able to colonise the gaps and produce vigorous plants with many seeds. These late-emerging plants can be very important for further infestations and in extending the population's

growing season. These observations highlight the importance of good crop establishment and early growth to minimise the open spaces that allow grass weeds to establish.

Farmers generally report fewer problems with these weeds after ploughing or burning stubble. Ploughing is known to cause weed seed distribution down the soil profile (Rahman et al. 2000). The fate of these buried seeds is a major determinant in the success of ploughing in the long term. Brome grasses studied in this report showed fatal germination or weaker seedlings when buried deeply, which can be used as part of their management. For non-inversion seed bed preparation, burning can be effective provided a dense, long straw is present.

REFERENCES

- Blackshaw RE, Hamman WM 1998. Control of downy brome (*Bromus tectorum*) in winter wheat (*Triticum aestivum*) with MON 37500. *Weed Technology* 12 (3): 421-425.
- Cheam AH 1986. Patterns of change in seed dormancy and persistence of *Bromus diandrus* Roth. (great brome) in the field. *Australian Journal of Agricultural Research* 37(5): 471-481.
- Cheam AH 1987. Longevity of *Bromus diandrus* Roth. seed in soil at three sites in Western Australia. *Plant Protection Quarterly* 2(3): 137-139.
- Dastgheib F, Rolston MP, Archie WJ 2003. Chemical control of brome grasses (*Bromus* spp.) in cereals. *New Zealand Plant Protection* 56: 227-232.
- Floyd AG 1966. Effect of fire upon weed seeds in the wet sclerophyll forests of northern New South Wales. *Australian Journal of Botany* 14: 243-256.
- Froud-Williams RJ 1981. Germination behaviour of *Bromus* species and *Aloperculis myosuroides*. Association of Applied Biologists Conference: Grass Weeds in cereals in the United Kingdom. Pp. 31-40.
- Gill GS, Blacklow WM 1985. Variations in seed dormancy and rates of development of great brome, *Bromus diandrus* Roth.,

- as adaptations to the climates of southern Australia and implications for weed control. *Australian Journal of Agricultural Research* 36(2): 295-304.
- Harradine AR 1986. Seed longevity and seedling establishment of *Bromus diandrus* Roth. *Weed Research* 26: 173-180.
- Hilton JR 1982. An unusual effect of the far-red absorbing form of phytochrome: photoinhibition of seed germination in *Bromus sterilis* L. *Planta* 155(6): 524-528.
- Hilton JR 1987. Photoregulation of germination in freshly-harvested and dried seeds of *Bromus sterilis* L. *Journal of Experimental Botany* 38(187): 286-292.
- Kleemann SGL, Gill GS 2006. Differences in the distribution and seed germination behaviour of populations of *Bromus rigidus* and *Bromus diandrus* in South Australia: adaptations to habitat and implications for weed management. *Australian Journal of Agricultural Research* 57: 213-219.
- Kon KF, Blacklow WM 1988. Identification, distribution and population variability of great brome (*Bromus diandrus* Roth) and rigid brome (*Bromus rigidus* Roth). *Australian Journal of Agricultural Research* 39(6): 1039-1050.
- Peters NCB, Atkins HA, Brain P 2000. Evidence of differences in seed dormancy among populations of *Bromus sterilis*. *Weed Research* 40(5): 467-478.
- Rahman A, James TK, Mellsop J, Grbavac N 2000. Effect of cultivation methods on weed seed distribution and seedling emergence. *New Zealand Plant Protection* 53:28-33.
- Rolston MP, Archie WJ, Reddy K, Dastgheib F 2003. Grass weed control and herbicide tolerance in cereals. *New Zealand Plant Protection* 56: 220-226.
- Simpson GM 1990. *Seed Dormancy in Grasses*. Cambridge University Press, Cambridge, UK. 297 p.