Brome Grasses as Weeds, Biology and Control

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TO
The Agricultural and Marketing Research and Development Trust
(AGMARDT)
Canterbury Grass Weeds Group
Foundation for Arable Research

EXECUTIVE SUMMARY

The project started in April 2002 and studied some aspects of biology and chemical control of brome grasses (*Bromus* spp.) in cereals. The major *Bromus* species in Canterbury are prairie grass (*B. willdenowii*), ripgut brome (*B. diandrus*) and soft brome or goosegrass (*B. mollis*). Seeds were collected from different locations for the study. Germination tests in the laboratory, pot experiments and a field experiment were performed to determine dormancy and emergence patterns of these populations. Six field trials in the first year (2002) and three in the second year (2003) were established to test the effect of various herbicide treatments on controlling brome grasses and on cereal crops. A number of promising chemical treatments were found which offer a good degree of control. It was found that effective control of brome grass requires sequential application of pre- and post-emergence herbicides. Yield comparisons between weedy and chemical treatments showed that brome grasses are very competitive weeds. The results were demonstrated to farmers in field days and were published in a farmer's magazine. Moreover, a scientific paper was presented to the New Zealand Plant Protection Conference in August 2003 and was published in their proceedings. The report concludes with recommendations for further study of grass weeds.

INTRODUCTION

Brome grass is emerging as a major challenge for arable farmers because there is no effective herbicide for its control in cereals. Several species of brome grass have already established in cropping farms of New Zealand. Visits to farms in Central Canterbury identified three species as the most common: ripgut brome (*Bromus diandrus*), soft brome (*B. hordeaceus*) and prairie grass (*B. willdenowii*). These grasses pose a major challenge for cereal growers as there is no registered herbicide which provides effective and safe control. This study was undertaken to search for chemical options for the control of brome grasses in wheat and barley. In 2002/03 field trials demonstrated the competitive nature of ripgut brome and showed the importance of pre-emergence treatments based on Gardoprim and a few post-emergence sequences (Dastgheib 2003 Annual Report, and F.A.R. Arable Update, Cereals No. 128).

This report presents the results of the second round of field experiments on the biology of brome grass seed and on the performance of selected herbicides and herbicide mixtures on controlloing brome grasses in wheat and barley.

METHODOLOGY

Seed Biology Studies

Seed Collection

In the second year, seeds were collected from 13 different populations of brome grass as shown in Table 1. There were seven populations of ripgut brome (*B. diandrus*), four of prairie grass (*Bromus willdenowii*) and two of soft brome (*B. mollis =B. hordeaceous*).
Seed heads were collected on 12 February 2003 and stored at room conditions.

Table 1. Description of brome grass seeds collected for studies

Species	Location	Farm owner	Designation
B. diandrus	Rakaia	Paul Wilkinson	PW2
	Rakaia	Paul Wilkinson	PW4
	Eiffleton	John Chynoweth	JC1
	Lauriston	Graeme Robertson	GR1
	Methven	David Grant	DV1
	Methven	Craig McKenzie	CM1
	Methven	Craig McKenzie	CM2
B. willdenowii	Rakaia	Paul Wilkinson	PW3
	Wakanui	David Fisher	DF1
	Methven	David Grant	DV2
	Methven	Craig McKenzie	CM4
B. mollis	Eiffleton	John Chynoweth	JC2
	Methven	Craig McKenzie	CM3

Emergence Pattern

A field experiment was established to study the emergence pattern of the above populations under natural conditions. One hundred seeds of each population were sown by hand in rows of five-meter length on 29 May 2003. The experiment had four replicates. Emerged seedlings in each row were counted and removed on 29 July and

5 September. No more seedlings emerged after this date. Percent emerged seedlings from the total was calculated for each date and the data were analysed through ANOVA.

Chemical Control Studies

General

Three field experiments were conducted in different locations in Central Canterbury as described in Table 2. The trials at Somerton were on dryland farms at the sites where data were collected the previous year; while the third site (Rokeby) was irrigated. All experiments had four replications and were laid in completely randomised blocks. Plot width was 2.25 m and plot length ranged from 7 to 15m. The herbicides used and their active ingredients are listed in Table 3. Herbicides were applied with a gas-propelled sprayer delivering 220 L/ha at 250 kPa using a four-nozzle 2-m wide boom, with XR Teejet flat spray tip 110-02 nozzles.

Crop tolerance and brome control were visually assessed. Brome density was counted using quadrats (0.25 m^2). Weed and crop dry weight mass was determined in one trial. Grain yield was harvested in the two wheat trials with a Wintersteiger 'Elite' plot combine. In the barley trial, grain yield was measured by sampling 2 m^2 per plot. The grain from each plot weighed and seed moisture determined and grain yields were corrected to 14% moisture content.

All fields had a history of natural infestation of brome grass. However, the site in Rokeby did not show any brome this year contrary to the farmer's expectation and experience.

Table 2. Details of trial sites for chemical control experiments.

Designation	Location	Farm manager	Crop
Trial 1	Rakaia, Somerton	Paul Wilkinson	Wheat
Trial 2	Rakaia, Rokeby	Stewart Parkinson	Wheat
Trial 3	Rakaia, Somerton	Paul Wilkinson	Barley

Table 3. Active ingredient and formulation details of herbicides used in trials.

Trade name	Common name and formulation
Avadex	500 g/L triallate (EC*)
Bladex	500 g/L cyanazine (SC*)
Escort	600 g/kg metsulfuron (WDG*)
Gardoprim	500 g/L terbuthylazine (SC)
Glean	750 g/kg chlorsulfuron (WDG)
Sencor	700 g/kg metribuzin (WDG)
Topogard	350 g/L terbytryn + 150 g/L terbuthylazine (SC)
Turonex	500 g/L isoproturon with 80 g/L ethylene glycol (SC)

* EC = emulsifiable concentrate, SC = suspension concentrate, WDG = water dispersible granules

Trial 1

The trial was established in direct drilled wheat cv "Domino" sown on 15 June 2003 at Somerton in a paddock with a history of ripgut brome. This paddock was also used for our 2002 trials. The trial evaluated eighteen herbicide treatments (with eight herbicides) including pre- and post emergence applications and two control plots per replicate to ensure a more accurate estimate of a natural and variable population of weeds. There were four replicates in a randomised block design. The herbicides used and application rates are listed in Table 4. Application dates were: pre-emergence 19 June 03 and post emergence 25 August 2003 when brome had 1-3 leaves, Zadoks Growth Stage (ZGS) 13; and wheat had 1 tiller (ZGS 21). Plots were evaluated for herbicide damage to the crop, brome density (based on counts in two 0.25-m^2 quadrats per plot) and visual assessments. Grain yield was determined by harvesting the plots as described above on the 6 February 2003.

Trial 2

The trial was established in wheat cv "Torlesse" sown on 8 August 2003 at Highfield Farm, Rokeby in an area which had had a history of ripgut brome. The crop received three irrigations each 35 mm (total 105 mm). The same herbicide treatments as Trial 1 were used with pre-emergence applications on 19 August and post-emergence applications on 6 October when wheat was at ZGS 21. Herbicide treatments and rates are listed in Table 5.

Trial 3

This trial evaluated six post-emergence herbicide treatments against ripgut brome in direct drilled barley cv "Optic" sown in late August 2003 at Somerton in a paddock with a history of ripgut brome. The herbicides used and rates are listed in Table 6. All herbicides were applied on 14 Oct 2003 when barley had 4 leaves (ZGS 14). Herbicide effects were assessed by counting brome plants in 0.25-m^2 quadrats and by visual assessments of barley crop, brome and broadleaf weeds on 19 Dec. Plots were hand harvested with 2 x 1-m2 quadrats from each plot in early February.

RESULTS

Seed Biology Studies

Emergence pattern of three species of brome (a total of 13 populations) was studied in a field experiment during winter 2003. Three weeks after sowing (29 May), between 54 to 79% of the total had emerged and by three months after sowing (29 July) another 8-31% emerged bringing the total emerged to 85-90% (Table 4). Emergence continued for another month, and 9-18% new seedlings were observed by September with no further emergence. In the first and second dates, there were some differences between populations within each species. The lowest percent emergence on 29 May was observed in the population CM4 of prairie grass. Ripgut brome showed more consistent pattern with most populations showing near or above 70% emergence at the first count. No significant differences were found between populations at the last count.

Table 4: Emergence of 13 different populations from three species of brome grass during the autumn-winter period in 2003.

		Mean % emergence		
Species	**Population**	**29-May**	**29-Jul**	**5-Sep**
B. diandrus	CM1	69.7	21.2	9.1
	CM2	78.0	9.8	12.2
	DV1	79.4	11.0	9.6
	GR1	71.9	9.4	18.7
	PW2	71.2	17.3	11.5
	PW4	72.6	15.6	11.7
	JC1	72.0	14.9	13.1
B. willdenowii	CM4	54.3	31.3	14.4
	DV2	74.1	9.9	15.9
	DF1	67.1	14.2	18.7
	PW3	71.0	12.0	17.0
B. mollis	CM3	73.8	8.0	18.2
	JC2	67.4	14.7	17.9
	LSD	10.59	8.38	ns
	p-value	0.0044	5.7E-05	0.28

Figure 1 shows the cumulative emergence for each species mean during the experimental period. When all populations within each species were pulled together no differences in emergence pattern were observed between the three species. As a mean of all populations, between 67 to 74% emergence was observed in May. This increased to 82 to 88% by the end of July and to 100% by September (Fig.1).

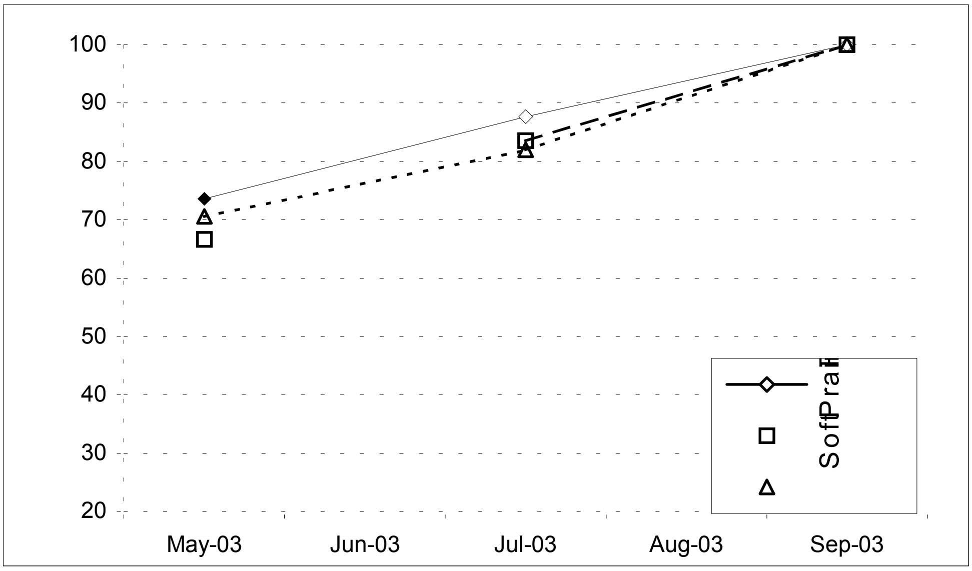

Fig.1: Emergence of three species of brome grass during the winter in the field experiment. Data points are mean of all populations tested.

Chemical Control Studies

Trial 1

Ripgut brome levels at this site were lower than the previous year. Control plots averaged 17 bromes/m^2 compared with 37/m^2 the previous year in the same paddock. Most treatments caused a significant reduction in the number of brome grass plants compared to the control as measured 12 weeks after post-emergence application (Table 5). All treatments reduced dry matter of brome grass compared to the control.
Only two treatments gave 100% control of brome grass. These were
Gardoprim + Glean pre → Sencor post, and Gardoprim + Glean pre → Gardoprim + Topogard post.
Several other treatments also gave high level of brome control, i.e; only one or two bromes/m^2 (88 to 94% control). These were Gardoprim pre → Gardoprim + Glean post, Topogard pre → Gardoprim post, and Topogard pre → Gardoprim post. It is noteworthy that the farmer's treatment (Gardoprim + Simazine) gave a moderate reduction in brome density.
The treatments which did not reduce brome grass density were Topogard pre-emergence, Avadex pre followed by Turonex + Glean post-emergence and the three-way mixture of Glean + Escort + Sencor applied post-emergence.

Major broadleaf weeds in the trial site included shepherd's purse (*Capsella bursa-pastoris*), chickweed (*Stellaria media*), field pansy (*Viola arvensis*) and cleavers (*Galium aparine*). All treatments provided effective control of broadleaf weeds present. Among these, six sequential applications had no broadleaf weeds and other sequential treatments gave near complete control (Table 5).

Trial 2

Despite a history of brome at the trial site, no brome was observed (Table 6). There is no clear explanation for this; but it is possible that ripgut brome is strongly a winter annual germinating predominately in the autumn and early winter and was killed by pre-sowing cultivation for this late crop.

Among the broadleaf weeds, cornbind (*Polygonum convulvlus*) was very common and any treatment with Gardoprim+Glean either pre- or post-emergence had very low populations of cornbind. Field pansy and other weed species were also well reduced by this mixture (Table 6).

Early observations showed that Topogard applied pre-emergence checked wheat growth but the crop outgrew the damage after a few weeks. Plots receiving Gardoprim+Sencor also showed a lot of damage to wheat but this was more long term and caused a non-significant yield reduction. There was a reasonable amount of variation in the trial (CV=17%), in part associated with a concentration of higher yielding plots in the centre area of the trial. Using a covariate analysis for yield adjustment, the CV was reduced to 13% without changing the treatment ranks (Table 6). The toxicity of Gardoprim + Sencor to wheat is apparently cultivar dependent and Torlesse seems to be more sensitive than other cultivars.

Table 5. Density and dry weight of broadleaf weeds (BL) and ripgut brome, and biomass of wheat measured on 24 Nov 03 and final grain yield in trial 1

Pre-Em.	Rate (g/ha)	Post-Em.	Rate (g/ha)	brome (No./m2)	brome (DW/m2)	BL weeds (No./m2)	BL weeds (DW/m2)	wheat DW/m2	Grain Yield (T/ha)
Nil	0	nil	0	17	31.2	88	20.2	463	3.23
Grdpm	1500	nil	0	8	10.6	13	0.2	525	3.35
Grdpm	1500	Grdpm	1500	3	2.7	0	0	521	3.71
Grdpm	1500	Grdpm+Glean	1500+15	1	0.7	0	0	518	3.60
Grdpm+Glean	1500+15	Grdpm	1500	3	3.1	1	0.1	499	3.49
Grdpm+Glean	1500+15	Sencor	750	0	0.0	0	0	584	3.75
Grdpm+Glean	1500+15	Topogard	2500	3	1.6	0	0	465	3.57
Grdpm+Glean	1500+15	Grdpm+Topogard	1500+2500	0	0.0	0	0	446	3.43
Grdpm+Glean	1500+15	Turonex	3000	5	6.7	5	0.6	534	3.63
Grdpm	1500	Turonex+Glean	3000+15	2	1.9	4	0.5	547	3.76
Topogard	2500	nil	0	12	14.9	32	2.6	507	3.58
Topogard	2500	Grdpm	1500	1	3.1	2	0.2	562	3.54
Topogard	2500	Grdpm+Glean	1500+15	2	1.1	0	0	508	3.62
Avadex	3500	Turonex+Glean	3000+15	15	18.9	6	0.9	512	3.31
Glean+Escort+Sen	23+5+280	nil	0	7	7.0	23	3.4	467	3.29
Nil	0	Glean+Escort+Sen	23+5+280	10	7.7	2	0.1	449	3.20
Bldx+Grdpm	600+900	nil	0	7	7.0	26	4.8	523	3.51
Grdprm+Simazine	1250 + 400	nil	0	5	8.6	14	4.3	486	3.32
			LSD 5%	8	11.6	25	4.0	ns	ns

Table 6. Density of cornbind and other broadleaf weeds (BL) and crop growth score measured on 18 Nov 03, weed control score measured on 19 December 03 and final grain yield in trial 2

Pre-em.	Rate (g/ha)	Post-em.	Rate (g/ha)	cornbind /m2	other BL /m2	control score[1]	crop score[1]	Yield[2] T/ha
Nil	0	nil	0	38	101	1	8.5	7.57
Grdpm	1500	nil	0	28	12	8.8	8.3	7.98
Grdpm	1500	Grdpm	1500	6	6	8.5	7.3	7.66
Grdpm	1500	Grdpm+Glean	1500+15	0.5	0	10	6.8	7.52
Grdpm+Glean	1500+15	Grdpm	1500	0.5	6	9.8	8.0	8.64
Grdpm+Glean	1500+15	Sencor	750	2.5	1	10	7.5	6.81
Grdpm+Glean	1500+15	Topogard	2500	0	4	10	7.5	7.78
Grdpm+Glean	1500+15	Grdpm+Topogard	1500+2500	0	0	10	5.3	6.62
Grdpm+Glean	1500+15	Turonex	3000	8.5	9	9.5	7.8	7.79
Grdpm	1500	Turonex+Gln	3000+15	6.5	14	9.3	8.8	8.16
Topogard	2500	nil	0	13	20	7.5	8.8	8.60
Topogard	2500	Grdpm	1500	1.0	1	9.8	8.3	8.65
Topogard	2500	Grdpm+Glean	1500+15	0	4	10	8.3	7.78
Avadex	3500	Turonex+Gln	3000+15	13	61	6.8	8.0	9.13
Gln+Escort+Sen	23+5+280	nil	0	8.5	23	8.8	8.3	7.72
Grdpm+Sencor	1000+500	Gln+Escort+Sen	23+5+280	1.5	0	10	5.8	6.66
Bldx+Grdpm	600+900	Nil	0	0	35	6.5	8.3	7.84
Grdpm+Sencor	1000+750	Nil	0	10	10	9	5.3	6.52
LSD 5%				19	51	2.29	2.4	1.48

[1] Weed control score: 1=weedy, 10=good control; Crop growth score: 1=poor, 10 =good, [2] covariate yield adjustment

Trial 3

Only post emergence applications were made and only one treatment, a mix of Gardoprim + Sencor was very effective, reducing brome by 98.5% (from 45 to 0.7 plants/ m^2). Several of the other treatments significantly reduced brome numbers, the level of control in these treatments were between 55 and 60% (Table 7). In last year's trial Topogard alone as a post-emergence application gave excellent brome control, but this result has not been repeated in this trial.

The severe effect of the drought on this dryland crop makes crop damage difficult to interpret. The data suggest that while the Gardoprim+Sencor mix gave the best brome control, there may be issues with crop tolerance in barley as this treatment had a significantly lower crop vigour score (Table 7). However, because grain yield was seriously affected by the drought, the differences between treatments were masked.

Table 7. **Density of ripgut brome (18 Nov), broadleaf (BL) weed control and crop vigour scores (19 Dec) and final grain yield in trial 3**

Post-emergence treatment	Rate (g/ha)	No. brome/m^2	BL Weed score[1]	Crop score[1]	Grain yield (T/ha)
Nil	0	45	2.3	9.7	1.66
Sencor	750	20	7.7	8.3	1.90
Gardoprim + Glean	1500 + 15	18	6.7	9.0	1.41
Gardoprim + Sencor	1500 + 750	0.7	9.0	7.0	1.42
Topogard	2500	18	7.7	7.3	1.34
Sencor+Glean+Escort	500+23+5	27	8.7	9.0	1.38
Gardoprim + Bladex	1000 + 1000	45	6.3	9.0	1.38
Gardoprim + Simazine →Cougar + Simazine[2]	1000 + 300 300 + 300	24	7.3	9.3	1.68
LSD 5%		20	2.2	1.1	NS

[1] weeds scores; 1=weedy; 10=good control; barley crop growth; 1=poor; 10 = good.
[2] Farmer's treatment

DISCUSSION AND RECOMMENDATIONS

Weather and brome infestations

December 2003 was the driest recorded for more than 100 years in Canterbury, while the whole spring and early summer was very dry. Moisture stress during reproductive development had a severe impact on the yield of the two dryland crops with wheat averaging 3.5 t/ha and barley 1.4 t/ha.

Ripgut brome levels recorded in the trials were lower than the previous year. In Trial 1, control plots averaged 17 bromes/ m^2 compared with 37/ m^2 the previous year in the same paddock. Visual observations on trial 3, suggest that while a moderate infestation occurred (44 plants/m^2 Farmer's treatment), this was restricted to a narrow strip along the front of the plots. The lower brome infestation and severe drought have resulted in less significant yield reduction compared to last year's trials.

Effective chemical treatments
A number of very effective treatments have emerged as a result of the study.

In general, sequential treatments showed better brome control than either a single pre-emergence or a single post-emergence treatment.

The following treatments gave between 88 and 100% control of ripgut brome

- Gardoprim + Glean Pre → Sencor Post
- Gardoprim + Glean Pre → Gardoprim + Topogard Post
- Gardoprim Pre → Gardoprim + Glean Post
- Topogard Pre → Gardoprim Post
- Topogard Pre → Gardoprim Post

All treatments that received a sequential herbicide treatment had near complete control of broadleaf weeds.
Timing of post-emergence application is important and while it maybe useful to wait until majority of brome seeds in the soil seed bank have emerged, unnecessary delay in post-emergence application will reduce herbicide efficacy.

An important factor in choosing the right chemical treatment for brome grass control is crop selectivity. Previous studies[1] have shown that some barley and wheat cultivars are more sensitive to certain herbicides and this year's trials showed that the mixture of Gardoprim + Sencor affected growth and yield in Optic barley and Torlesse wheat. Herbicide rate is a major factor here and some farmers have experienced crop damage with Gardoprim at rates above 1 L/ha.

Seed biology applications
The experiments from both years showed that although certain populations had rather low germination, most populations had little initial dormancy. In general, very little difference in seed dormancy and emergence patterns was noticed between different populations of three species of brome grass studied. Under field conditions, we can expect majority of seeds to emerge by mid-winter. This allows controlling them with general weed killers or normal surface cultivation in a properly timed stale seed bed. Last year's study showed that when seeds were buried to depths of 80 or 120 mm, only 19 or 2% emergence occurred respectively. This seems to be why brome grass is more troublesome in no-tillage systems. However, considering the benefits of no-tillage from the conservation viewpoint, one should seek suitable management techniques to be used in these systems.

FURTHER WORK

The results with post-emergence applications of Topogard and Bladex+Gardoprim were markedly different between the two seasons of this study. These treatments were much more effective in 2002 and it is worth to investigate reasons for inconsistent results.

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[1] Rolston, M.P., Archie, W.J., Reddy, K. and Dastgheib, F. 2003. Grass weed control and herbicide tolerance in cereals. *Proceedings of 56th New Zealand Plant Protection Conference* (August 12-14, 2003): 220-226.

The most effective herbicide mixtures mentioned above all contain chemicals from the same chemical family, the triazine group. It is known that applying herbicides from one chemical group every year will increase the likelihood of developing herbicide-resistant weeds. It is therefore important to try and identify herbicides from other chemical groups with efficacy on brome grass so that farmers have more options.
Brome infestations usually start from the fencelines and headlands and gradually move into the field. Burning stubble usually eliminates plenty of brome seeds on the soil surface, but the headlands are fire breaks and not burnt. Overseas reports indicate that brome seeds move up to 1.8 m by rotary harrow and up to 20 m by combine harvester. This means management practices in the headlands are important in limiting the infestation. In particular at the harvest time, extreme care should be taken not to move the combine from the infested part directly into the middle of the field.

More study on seed biology of brome grass species is warranted especially determining seed longevity which might offer recommendations for long-term management practices to minimise their infestation.

Considering the importance of avoiding repeated applications of herbicides from the same group (see above), an integrated weed management strategy which reduces herbicide input should be sought. Overseas reports show that higher sowing rates and better placement and timing of nitrogen fertiliser can enhance wheat competitiveness with brome grasses. Delayed planting might be effective in certain cases, but the risk of yield penalty exists. Moreover, cover crops in the summer-autumn period might offer opportunities for controlling brome before winter wheat. These options need to be tested in future.

TECHNOLOGY TRANSFER

A successful field day was held on 28 November 2003 as part of "Rakaia Farmers Field Day". This was the second time the brome control project was demonstrated in this popular farmers' meeting. Attendants made first hand observation on the treatment effects in the field and had plenty of opportunities for discussion.

Foundation for Arable Research published the results of the first round of experiments in their Arable Update which is mailed out to more than 2500 subscribers (FAR Arable Update, Cereals, No.128, April 2003; copy attached).

A scientific paper[2] was presented at the New Zealand Plant Protection Conference and published in their proceedings (copy attached).
The project was also reviewed by one of the candidates for the Wrightson-AGMARDT Young Farmer of the Year Competition.

ACKNOWLEDGEMENT

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[2] Dastgheib, F. Rolston, M.P. and Archie, W.J. 2003. Chemical control of brome grasses (*Bromus* spp.)in cereals. *Proceedings of 56th New Zealand Plant Protection Conference* (August 12-14, 2003): 227-232.