# MALLEE ROTATIONS THAT BEAT BROME GRASS AND MAKE MONEY

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## TAKE HOME MESSAGES

- In years with high summer rainfall, growing break crops is low risk and is an effective management strategy for reducing weeds, while growing profitability.
- Two year breaks are better than one at achieving favourable returns and reducing brome grass populations.
- The best brome grass control and gross margins were achieved by two year rotations of Clearfield canola/vetch and continuous Clearfield wheat followed by wheat.

## KEY WORDS

Brome grass, crop sequences, profitability, resistance, risk, rotations, soil moisture, soil nitrogen, weed seed bank.

## BACKGROUND

The GRDC-funded crop sequencing trial at Chinkapook is investigating one and two year break crop sequences. Specifically the trial is looking at the impact of non-cereal crop rotations and cereal sequences that use group B herbicides for brome grass control. In the third year of this four year investigation, the yield and profitability of wheat grown after these sequences was measured. Central to this study was the profitability of each three year sequence and its influence on brome grass, soil water and nitrogen.

When the trial commenced in 2011, substantial summer rainfall had increased soil moisture. This gave growers confidence to sow canola, chickpeas, and lentils in paddocks long overdue for an alternative break crop. It was a similar story for many areas leading into the 2012 season. However, the 2012/13 summer was one of the driest experienced and the risk of growing high input crops was likely to increase.

In the Mallee, break crops are perceived to be of greater risk than cereals, mainly due to higher input costs and the increased chance of crop failure. Given this premise, the Mallee has been dominated by paddocks of continuously cropped cereals. This has encouraged brome grass to develop as a problematic weed, particularly on sandy rises where crop competition can be poor. The use of brome grass selective herbicides and herbicide tolerant Clearfield technology has therefore increased. This, in turn, has led to more group B herbicide use and subsequent resistance development.

Brome grass by nature is highly competitive. Two to three consecutive years of brome seed-set prevention are necessary to reduce the seed bank population. A population of 100 plants/m$^2$ leads to an average yield loss of 30 per cent (%) in wheat crops due to its high level of competitiveness for water, nutrients and space (*Gill et al. Poole and Holmes, 1987*).

This project attempts to determine:

a. Whether positive break crop influences on soil nutrition, weed resistance, herbicide rotation and profitability can be achieved and if the benefits outweigh the perceived risks; and

b. If selective herbicides and the use of herbicide tolerant cereals and canola can help to reduce brome grass weed populations.

BCG, through the Low Rainfall Collaboration Group, received GRDC funding for a five-year project (field work 2011-2014) to investigate alternative break crop options and sequences for maintaining profitability and managing brome grass populations in the Mallee.

## AIM

To investigate alternative break crop sequences and cereal herbicide control options that can increase profitability and reduce brome grass populations in the Mallee.

## METHOD

In 2011, a four year trial was established in a long-term cereal paddock at Chinkapook in a typical dune-swale Mallee landscape. One and two year non-cereal break crops or cereals with group B herbicide applied to target brome grass were established. Various crop types, chemical groups and management options were compared via three complete randomised blocks. Plot size was 2.5m x 20m.

On 9 April 2013, in the third season of this trial, top-soil was collected to measure baseline weed seed bank, soil biology and root disease levels. Soil nutrition and moisture were measured to depth. Brome grass populations were evaluated on 18 June, 23 July and 29 August.

Yield, quality and gross margins were statistically analysed. Gross margins were calculated and seed prices per tonne obtained from the 2011, 2012 and 2013 '*Farm Gross Margin and Enterprise Planning Guides*' (Rural Solutions SA. 2011, 2012, 2013). Chemical prices were acquired from a Birchip chemical reseller. Income was calculated using a mix of cash at silo, farm gross margin and enterprise planning guide and district average prices.

Findings from this project will be used for crop sequencing modelling. This trial will be sown to wheat in 2014.

| | | |
|---|---|---|
| Location: | Chinkapook | |
| Sowing date: | 9 April | |
| Target plant density: | 50 plants/m$^2$ | |
| Wheat variety: | Grenade CLF Plus | |
| Fertiliser: | 1 May | Supreme Z Granulock (48kg/ha) |
| | 12 July | Urea (70kg/ha) + SLAM (25kg/ha)<br>(2012 cereal and canola treatments only) |
| Herbicides: | 9 April | glyphosate (2L/ha) + Goal® (100ml/ha) + Hasten (1%)<br>(summer fallow treatment) |
| | 1 May | glyphosate (2L/ha) + TriflurX® 2L/ha |
| | 26 June | Velocity® (670ml/ha) (self-sown canola, wild turnip) + MCPA LVE 600 (350ml/ha) + Lontrel (100ml) (medic, vetch), Hasten (0.5%) |
| Seeding equipment: | Knife point, press wheels, 30cm row spacing. | |

**Table 1. 2011 and 2012 treatment descriptions (one and two year break descriptions include both legume and brome grass breaks).**

| Treatments | 2011 Crop | 2012 Crop |
|---|---|---|
| CLF wheat/CLF wheat (2 year herbicide control) | Wheat (CLF_STL) | Wheat (CLF_Elmore) |
| Wheat+Atlantis/CLF barley (2 year herbicide control) | Wheat (Atlantis herbicide applied) | Barley (Scope CL) |
| Field peas/wheat (1 year break crop) | Field Peas (Kaspa) | Wheat |
| Chemical fallow/wheat (1 year break crop) | Chemical Fallow | Wheat |
| CLF canola/vetch (2 year break crop) | Canola (Clearfield 43C80) | Vetch (Morava) |
| TT canola/field pea (2 year break crop) | Canola (Monola 76TT) | Field pea (Kaspa) |
| CLF wheat/chickpeas (1 year herbicide,1 year break crop) | Wheat (CLF_STL) | Chickpeas (CICA 603) |
| Chemical fallow/CLF canola (2 year break crop) | Chemical Fallow | Canola (CLF_44Y84) |
| Vetch hay/CLF canola (2 year break crop) | Vetch (Morava) Hay | Canola (CLF_44Y84) |
| Lupins/CLF canola (2 year break crop) | Lupins (Mandelup) | Canola (CLF_44Y84) |
| Hay/hay (2 year break) | Oats/Vetch | Canola (Stingray)/ Vetch (Morava) mix |
| Medic/medic (2 year break) | Medic (Mulga) | Medic (Mulga) |
| Vol. pasture/vol. pasture (2 year break) | Volunteer pasture | Volunteer pasture |
| Wheat/wheat (nil control) | Wheat | Wheat |
| Chem fallow/chem fallow (2 year herbicide control) | Chemical fallow | Chemical fallow |

In 2013 wheat (Grenade CLF Plus) was grown on all treatments (but Clearfield herbicide was not used) to measure the influence of each crop sequence on soil water, nitrogen and brome grass populations. The difference between each sequence was measured by 2011-2013 yield and gross margins.

## RESULTS AND INTERPRETATION

### *Chinkapook Rainfall*

The 2011 season was excellent for crop growth with both high summer and growing season rainfall. In 2012, summer rainfall was the driver for crop growth as the GSR was only Decile 2. In 2013 summer rainfall was much lower (Decile 3) and neither weeds nor self-sown cereals emerged prior to sowing. Decile 4 GSR would have governed plant growth, together with any residual soil moisture carried over from the previous years.

**Table 2. Chinkapook rainfall for 2011, 2012 and 2013.**

| | 2011 | Decile | 2012 | Decile | 2013 | Decile |
|---|---|---|---|---|---|---|
| Summer (mm) | 129 | 10 | 105 | 9 | 31 | 3 |
| GSR (April-October) (mm) | 219 | 7 | 117 | 2 | 168 | 4 |
| Annual (mm) | 421 | 9 | 222 | 2 | 246 | 2 |

*Deciles obtained from the Rainman computer program using long-term rainfall from Manangatang.

**Table 3. 2013 Chinkapook monthly rainfall**

| Rainfall | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 5 | 17 | 9 | 8 | 22 | 54 | 26 | 17 | 30 | 11 | 5 | 42 |

## *2013 wheat yield and gross margin*

The treatments with the highest yields and gross margins did not grow grain crops in 2011 or 2012 (Table 4). Two years of chemical fallow yielded more than all other treatments, while the two continuous pasture stands of medic and volunteer pasture followed in significance.

Interestingly, the lupin/CLF canola sequence (two year break) yielded similar to the pasture.

The highest 2013 gross margin was achieved by the long chemical fallow ($570/ha) which was similar to the pasture treatments (medic $505/ha, volunteer pasture $491/ha).

Wheat following two year break and hay treatments yielded more than wheat following one year break options. Vetch hay/CLF canola was the only exception to this.

The gross margins for wheat after all two year break crop sequences were higher than one year break and continuous cereal sequences, with vetch hay/CLF canola being the only two year break exception.

Continuous wheat with no selective grass herbicides applied yielded the least (1.0t/ha). It was 1.3t/ha and 2.5t/ha lower in yield than continuous wheat with brome grass herbicide control and the long fallow respectively. A major yield and gross margin penalty ($271/ha) was incurred in a continuous cereal phase if brome grass was not controlled.

## *2013 grain quality*

In terms of quality, long chemical fallow and vetch hay/CLF canola were the only treatments to achieve protein levels sufficient to qualify for APW 1 (Table 4), which suggests these treatments had a higher concentration of plant nitrogen during grain fill. The continuous cereal treatment was contaminated with self-sown barley, which may have contributed to the lower protein and test weight.

**Table 4. 2013 brome populations, yield and quality of wheat.**

| Treatments | Final brome count 28 September 13 | 2013 Yield (t/ha) | 2013 Protein (%) | 2013 Test wt (kg/hL) | 2013 Screenings (%) | 2013 Gross margin* ($/ha) |
|---|---|---|---|---|---|---|
| CLF wheat/CLF wheat | 6$^{e}$ | 2.3$^{de}$ | 9.7$^{bc}$ | 82$^{a}$ | 3 | 290$^{e}$ |
| Wheat+Atlantis/CLF barley | 30$^{bcd}$ | 2.0$^{ef}$ | 8.6$^{e}$ | 78$^{c}$ | 4 | 234$^{ef}$ |
| Field Peas/wheat | 40$^{b}$ | 2.0$^{ef}$ | 9.6$^{bc}$ | 80$^{b}$ | 4 | 220$^{ef}$ |
| Chemical fallow/wheat | 36$^{bc}$ | 1.7$^{f}$ | 9.5$^{cd}$ | 81$^{ab}$ | 4 | 159$^{f}$ |
| CLF canola/vetch | 6$^{e}$ | 2.6$^{cd}$ | 9.7$^{bc}$ | 81$^{ab}$ | 4 | 454$^{bc}$ |
| TT canola/field pea | 8$^{ef}$ | 2.5$^{cd}$ | 9.5$^{cd}$ | 81$^{ab}$ | 3 | 425$^{bc}$ |
| CLF wheat/chickpeas | 12$^{bcde}$ | 2.5$^{cd}$ | 8.8$^{de}$ | 80$^{b}$ | 4 | 416$^{bc}$ |
| Chemical fallow/CLF canola | 16$^{cde}$ | 2.3$^{de}$ | 10.1$^{abc}$ | 81$^{ab}$ | 3 | 296$^{de}$ |
| Vetch hay/CLF canola | 9$^{e}$ | 2.2$^{de}$ | 10.6$^{a}$ | 81$^{ab}$ | 3 | 279$^{e}$ |
| Lupins/CLF canola | 6$^{e}$ | 2.7$^{bc}$ | 10.3$^{ab}$ | 81$^{ab}$ | 3 | 382$^{cd}$ |
| Hay/hay | 11$^{e}$ | 2.6$^{cd}$ | 10.3$^{ab}$ | 81$^{ab}$ | 3 | 439$^{bc}$ |
| Medic/medic | 9$^{de}$ | 3.0$^{b}$ | 9.9$^{bc}$ | 81$^{ab}$ | 2 | 505$^{ab}$ |
| Vol. pasture/vol. pasture | 6$^{e}$ | 3.0$^{b}$ | 9.5$^{cd}$ | 80$^{b}$ | 4 | 491$^{ab}$ |
| Wheat/wheat (nil control) | 450$^{a}$ | 1.0$^{g}$ | 8.7$^{e}$ | 80$^{b}$ | 5 | 19$^{g}$ |
| Chem fallow/chem fallow | 1$^{f}$ | 3.5$^{a}$ | 10.6$^{a}$ | 82$^{a}$ | 2 | 570$^{a}$ |
| Sig. diff. | P<0.001 | P<0.001 | P<0.001 | P=0.01 | NS | P<0.001 |
| LSD (P<0.05) | 13 | 0.4 | 0.7 | 2 | - | 90 |
| CV% | 31 | 9.9 | 4.4 | 1 | 29 | 16 |
| | **$Log_{10}$ P<0.001 | | | | | |
| | 0.54 | | | | | |
| | 31 | | | | | |

* Unfortunately at the time of publication, only input costs for pasture treatments were calculated (grazing value benefits were not yet calculated).

** Brome counts transformed by $Log_{10}$ for statistical differences, raw data presented in final brome count column.

## *Treatment effects on 2011, 2012, 2013 cumulative gross margins*

The highest cumulative gross margin (Figure 2) was CLF wheat/chickpeas ($1305/ha). This was similar to field peas/wheat ($1236/ha – one year break), CLF canola /vetch ($1221/ha – two year non-cereal break) and CLF wheat/CLF wheat ($1062/ha – two year brome herbicide break).

For the long chemical fallow ($489/ha), the high yields of 2013 were not sufficient to compensate for no income in 2011 and 2012, and the cumulative gross margin was similar to those sequences with the lowest gross margins.

Over three years, the difference in gross margins between controlling brome grass in wheat with herbicides and no brome grass herbicide control was $564/ha. To put it another way, the extra cost for the selective herbicide was offset by the increase in wheat yield and consequently the gross margin.

Lupins/CLF canola ($728) was the lowest performing two year break crop sequence and the low canola yield in 2012 may have been due to lower soil water following lupins (Figure 1).

Please note, unfortunately the grazing values of pasture treatments had not been calculated at the time of writing. As such, only input costs were included when statistical analysis was undertaken. However, a gross margin of approximately $180/ha (*Mudge pers. comm*) was suggested for prime lambs in the cereal zone, with rainfall from 250mm-450mm. If this value of $180/ha were to be extrapolated over the 2011 and 2012 season for the medic/medic phases and a slightly lower value of $160/ha for the two years of volunteer pasture, then the three year cumulative gross margin from 2011-2013 for medic would be $702/ha and the volunteer pasture $798/ha. This would then rate the volunteer pasture above the value of the lupin/CLF canola treatment and the medic just below.

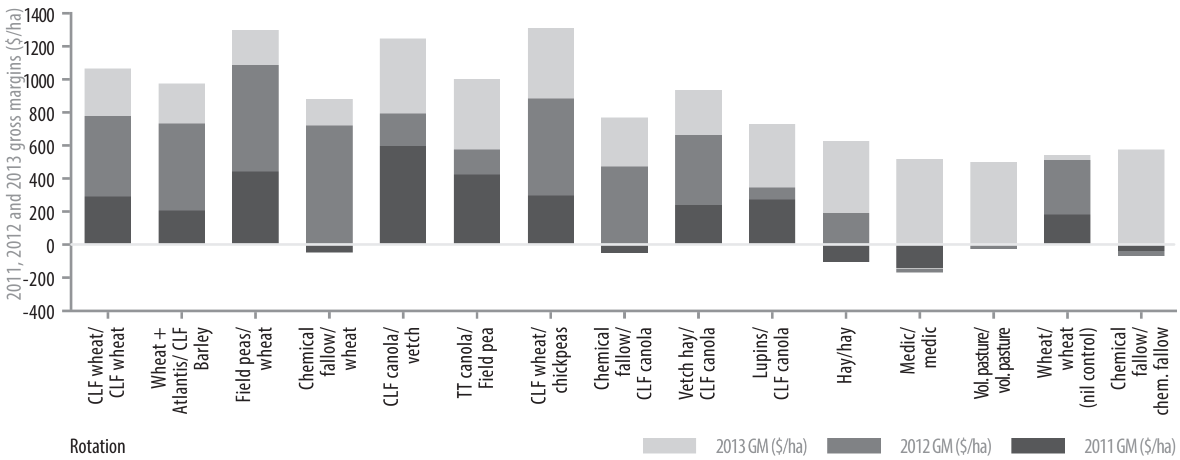


**Figure 1. 2011, 2012 and 2013 gross margins ($/ha). 2011 GM ($/ha): P<0.001, LSD=$116/ha, CV42%; 2012 GM ($/ha): P<0.001, LSD=$184/ha, CV35%; 2013 GM ($/ha): P<0.001, LSD=$90/ha, CV16%.**

## *2013 brome grass in-crop populations, 29 August 13 (Figure 2)*

On 29 August, high brome grass populations of 450 plants/$m^2$ resulted from the wheat sequence that had no herbicide brome control during 2011, 2012 and 2013.

The one year break sequence of field peas/wheat (40 plants/$m^2$), chem. fallow/wheat (36 plants/$m^2$) and the continuous cereal of wheat (Atlantis)/CLF barley (30 plants/$m^2$) also had higher brome grass populations than all remaining treatments.

Brome grass numbers had reduced to only 1 plant/$m^2$ in the long fallow.

## *2011, 2012, 2013 cumulative gross margins and brome grass populations (Figure 2).*

The treatment with the highest gross margin and medium-low brome numbers (12 plants/$m^2$) was the CLF wheat/chickpeas sequence. However, high gross margins were also achieved by the CLF canola/vetch and CLF wheat/CLF wheat and brome grass numbers of 6 plants/$m^2$ only.

The CLF canola/vetch gross margin was superior to vetch hay/CLF canola, although both sequences reduced brome grass populations.

Even though the one year break field peas/wheat sequence had a high gross margin, brome grass numbers were greater (brome grass 36 plants/$m^2$) than the other treatments already mentioned.

This suggests that two year break sequences that include legumes, Clearfield canola or Clearfield wheat can reduce brome grass numbers to low levels and be profitable. However, caution needs to be exercised if using group B herbicides for two years in a row or longer, as brome grass populations will develop herbicide resistance.

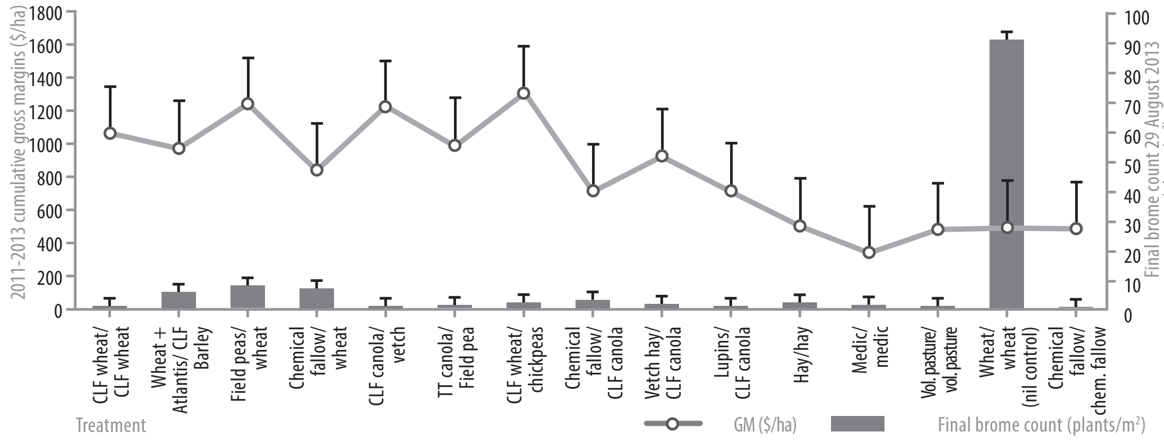


**Figure 2. 2011-2013 cumulative gross margin ($/ha) and final brome grass populations on 29 August 2013 (plants/m²). 2011-2013 GM ($/ha): P<0.001, LSD=$238, CV20%; final brome (plants/m²): P<0.001, LSD13 plants/m², CV=18%.**

### *2013 Pre-sow soil water and mineral nitrogen (0-100cm)*

The 2012/13 summer was dry. However, PAW ranged between 139mm (vetch hay/CLF canola) to 217mm (long chemical fallow). The long chemical fallow and volunteer pasture recorded the highest soil water and this was reflected in the high 2013 wheat yields.

Soil mineral nitrogen to depth ranged between 63kg N/ha (wheat/barley) and 136kg N/ha (long chemical fallow). It was also unlikely that much mineralisation had occurred prior to sowing. The long fallow had similar nitrogen content to the TT canola/field pea sequence. This similarity was not reflected in 2013 gross margins.

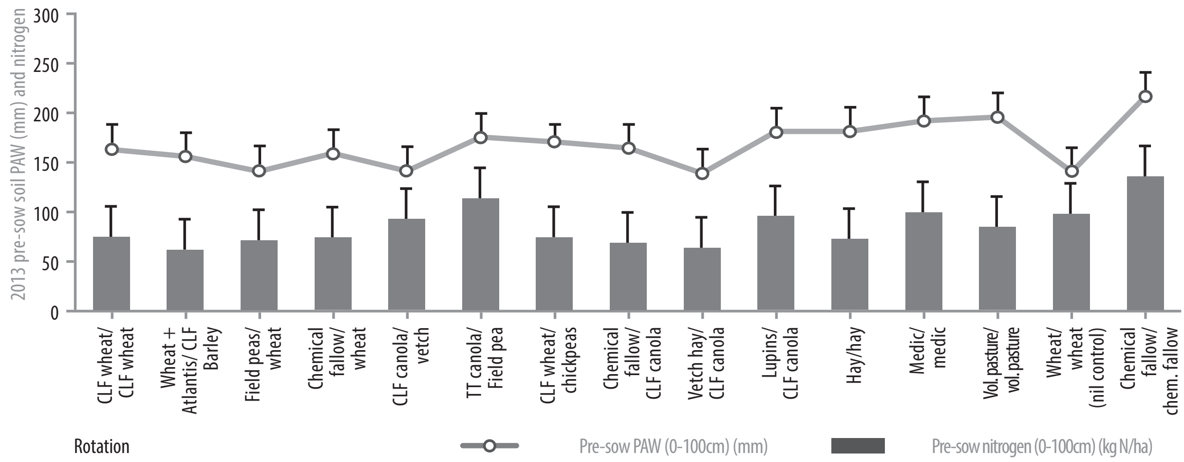


**Figure 3. 2013 pre-sow plant available water (PAW) and nitrogen (kg N/ha). 2013 pre-sow PAW (mm): P<0.001, LSD=25mm, CV9%; 2013 pre-sow soil nitrogen (kg N/ha): P<0.002, LSD=31kg N/ha, CV21%.**

## COMMERCIAL PRACTICE

This trial showed that after high summer rainfall, growing a break crop is low risk and an effective management strategy for reducing weeds, while providing profitable gross margins.

Clearfield canola followed by vetch and Clearfield wheat-on-wheat rotations effectively reduced brome grass numbers (brome grass 6 plants/m²) and were also profitable.

The most profitable treatment however was the CLF wheat/chickpea sequence. This sequence was also effective at reducing brome grass numbers (12 plants/m²). This would generally be considered a high input sequence, but in years in which soil moisture is abundant, the cost of inputs can be returned in increased yield. In this study, $500 per tonne was used as a price for chickpea grain, but the market for chickpeas has now fallen to approximately $380/tonne (January 2014). This highlights the need for sensitivity analyses to be undertaken for each commodity.

Two year breaks are better than one at achieving favourable returns and reducing brome grass populations. Two year breaks that include legumes and/or use Clearfield technology can reduce brome grass numbers to low levels and be very profitable. The lupin/CLF canola sequence was the least profitable (two year gross margin). It is possible that soil moisture was reduced following the lupin phase in year one. This requires further investigation.

Herbicide groups, particularly group B chemistry, should be rotated to reduce weed resistance. Calculations on pasture costs and benefits require further investigation, but brome grass numbers were substantially suppressed in this study. Evaluating the most effective two year crop sequencing breaks with the lowest versus highest input costs and associated risk would be of interest to growers. There is more data to be analysed for this study and a completed report will be available in the near future.

## REFERENCES

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## ACKNOWLEDGMENTS

This trial was funded by GRDC through the LRCG Crop Sequencing Project (DAS00119).