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Managing brome grass in the wheat:lupin rotation

By Aik Hock Cheam and Gurjeet Gill, Weed Research Officers, South Perth and Christine Zaicou, Research Officer, Geraldton

Some farmers and scientists are questioning the sustainability of the cereal:lupin rotation in the Western Australian wheatbelt.

Being a 'tight' rotation, its continuation is constantly under threat by disease, especially lupin root rots caused by Pleiochaeta (the brown spot organism) and Rhizoctonia fungi. To control disease, some farmers have lengthened the rotation to three years, such as wheat:wheat:lupins or wheat:barley:lupins. The longer cereal phase also helps to stabilise soil against wind erosion.

However, such rotations can lead to a rapid build-up of brome grass during the two consecutive years of cereals. The implications of these rotations on the severity of brome grass infestations need to be assessed carefully.

As long as brome grass persists, farmers will stay with the cereal:lupin rotation to control it.

The rotation offers the best method of brome grass control, it also controls cereal root diseases, improves soil fertility, and reliability of yield. It has been shown to be a sustainable system by some farmers who have successfully completed 10 cycles (20 years) of the rotation.

In this article, the authors discuss the important role of the wheat:lupin rotation in the management of brome grass.

Spread and persistence of brome grass

Brome grass has become a serious weed of cereal crops growing on sandy soils in the northern wheatbelt only comparatively recently. Although eight annual species of brome grass (Bromus spp.) have been recorded in Western Australia, only two of these, great brome (Bromus diandrus Roth) and rigid brome (B. rigidus Roth) are significant weeds of agriculture.

Of the two species in Western Australia, rigid brome is better adapted to cropping situations on the sandplain soils of the northern wheatbelt. Its slower breakdown in seed dormancy, protracted germination pattern and shorter life cycle favour its predominance on these soil types.

Protracted germination allows late-emerging plants to escape the effects of pre-sowing cultivations and subsequent treatment with knockdown herbicides. Rigid brome's shorter life cycle is better adapted to the shorter growing season of the northern wheatbelt because more brome grass seed is shed before crop harvest.

Apart from these differences, both species have persisted successfully for several reasons.

- Increased dependence on minimum tillage for cereal production and earlier seeding. Reduced soil disturbance maintains brome grass seeds at or near the soil surface, in a position suitable...
for seedling establishment. Although a large proportion of the brome grass seed bank germinates readily, early seeding offers less opportunity to kill the emerged seedlings, resulting in more in-crop infestations.

- **Reduced competition from other weeds.** Increased use of selective herbicides for control of other grasses and broad-leaved weeds has favoured the persistence of brome grass because, to date, the most used in-crop herbicides for cereals do not control brome grass well.

- **Decline in sheep numbers,** which has allowed brome grass to seed more profusely during the pasture phase.

- **Increased area being cropped,** which includes many paddocks of lighter soils, has favoured the spread and establishment of brome grass. Brome grass grows successfully on sandy soils for many reasons. It can extract nitrogen from these soils, while the reduced cultivation needed to control wind erosion favours its growth.

Moreover, the water repellence common in sandy soils can lead to staggered and patchy germination, thus making it more difficult to control the weed in one operation. Sufficient moisture appears to be the main requirement for germination, as brome grass seeds are no longer dormant by the break of the season, and will germinate rapidly in the presence of enough soil moisture.

The first flush of brome grass following the first rains in autumn and early winter is always the most prominent. In a dry start to the season, a greater proportion of the seeds show staggered germination, which may last until as late as August.

- **Inherent biological features,** such as a fast growth rate, drought tolerance, better tolerance of phosphorus deficiency than wheat and a responsiveness to nitrogen, have all favoured the success of brome grass as a weed.

When compared to the wheat crop, brome grass is better adapted to a late break or an early finish to the season.

**Brome grass control is a numbers game**

The key to controlling brome grass lies in controlling an existing population to prevent seed production. This will deplete the soil seed bank and reduce the infestation in the following year.

Seed is the only source of infestation by brome grass and therefore it should be the ultimate target of control efforts. Beating brome grass is a numbers game. It is mainly the input of new seed, rather than the carry-over of old seeds, which is responsible for its persistence.

There is little carry-over of brome grass seed in the soil beyond one season. Less than 1 per cent of brome grass seeds survive in the soil for two years under normal field conditions. By controlling the weed effectively in one season, it is possible to drastically reduce the population in the following year.

**Evaluation and integration of control methods**

A good range of options is available for control of brome grass. Each has an important place, but none on its own has provided satisfactory control. Brome grass persists mainly because of the lack of careful planning, poor management and failure to adopt an integrated control program.

It is not enough to control brome grass in the year when measures are applied to boost crop yield. A carefully planned integrated control program, to be adopted over several years, is essential for both best crop yield and suppression of brome grass.

Under the rotational system – cereals with pastures or cereals with non-cereal crops – farmers can use several weed control practices which may involve some combination of cultiva-
However, there is a need for caution, especially where ryegrass is also present in the weed community. Repeated application of grass-selective herbicides ("fops") can result in the development of resistance to one or in some cases several groups of herbicides.

The best time to control brome grass is in the year before cropping. Based on results from our research of various rotational systems, brome grass control is best under lupins, then pasture, with least control under a wheat crop (see Figure 1).

**The wheat-lupin rotation**

The best and fastest way to control brome grass is to include lupins in a cereal rotation. However, the choice of herbicides and timing of their application in the lupin phase determine the success of the wheat-lupin rotation (see Figure 2).

**Brome grass control in lupins**

Several herbicides will control brome grass in lupins. The standard technique is to apply simazine pre-sowing. Tank-mixes of simazine with Spray.Seed® or glyphosate is a popular combination to knock down weeds that have germinated already.

In a wet year when there is enough moisture in soil, the simazine kills most of the germinating brome grass and broad-leaved weeds, resulting in a significant reduction of the weed seed bank. This ensures good weed reduction in the following cereal crops. Unfortunately, even in a wet year, many lupin crops need a back-up for simazine, because there is enough brome grass to threaten crop yields and to produce fresh seeds to replenish the seed bank.

The staggered germination pattern, especially in B. rigidus, has partly contributed to the failure of simazine in lupin crops. To remove these late-emerging plants and other brome grass plants that survived simazine, use a selective grass herbicide as a follow-up treatment in lupin crops. Selective herbicides registered for post-emergence brome grass control in lupins are fluazifop-p (Fusilade®), haloxyfop (Verdict®) and quizalofop (Assure® and Targa®).

To get the best result, wait until most of the brome grass has germinated before spraying to avert any need for a follow-up. At least 50 L/ha of water must be used when spraying post-emergence herbicides for the most effective target coverage and weed control.

Selective grass herbicide must not be applied before simazine has finished working or the grass herbicide's effectiveness will be reduced. This is because the target grasses are under stress and are therefore unable to absorb and translocate the herbicide. Symptoms such as leaf-tip dieback and leaf browning indicate plants are still absorbing simazine. With lupins, the canopy closure can also keep soil covered during the growing season, thus shading out late-emerging brome grass and those that survived herbicide treatments within the crop.

A selective grass herbicide has other benefits. It helps to remove other grass weeds and self-sown cereals from the lupin crops. This will provide a disease 'break', especially against root diseases such as take-all, which is carried over on grasses and self-sown cereals. Take-all is one of the major barriers to the achievement of potential wheat yields, especially in higher rainfall areas.

In the wheat phase of the wheat-lupin rotation, one kill of brome grass with a knock-down herbicide before seeding is essential to maintain a brome grass population level of less than 10 plants per square metre. Densities of less than 10 plants per square metre have little effect on wheat yield, but they remain as the source of continuing weed problems. At present, there is no practical method of eliminating this small population of brome grass in the wheat phase following lupins. Its elimination is the key to the long-term solution for brome grass because of the virtual exhaustion of the seed reserves (see Figure 3).

No herbicides are registered for selective brome grass control in cereals, primarily because the tolerance of cereal crops to most of the promising herbicides is low. Two herbicides, metribuzin (Sencor®, Lexone®) and pendimethalin (Stomp®), have shown good levels of control but their effectiveness is...
Cereal stubble protects lupins from sand blasting and brown spot disease.

Root diseases are less common after a cereal crop than after pasture.

Broad-leaved weeds are reduced because they are controlled in the cereal phase.

Nitrogen build-up in clover pasture will encourage weeds in the lupin crop.

Easier penetration in cereal stubbles allows dry or early direct drilling.

However, growing lupins after pasture is a risky proposition. Experiments have shown that lupins following cereals on average yield 30 per cent higher than lupins following pasture. This is because:

- Rotating pasture with cereals also slows the rate of development of herbicide resistance in comparison with intensive cropping systems, which rely heavily on a selective grass herbicide for weed control. This is because the inclusion of pasture allows the use of grazing animals and pasture topping.

**Wheat:Pasture:Herbicides**

Apart from cereal:pasture and cereal:lupin rotations, a three-year rotation involving wheat, pasture, lupins is a good combination for control of brome grass in the pasture and lupin phases. This is supported by results from an intensive study in the northern wheatbelt (see Table 1).

Rotation of lupins with legume pastures is not acceptable to many farmers because they prefer to alternate nitrogen-fixing plants with nitrogen-using plants. Nevertheless, our results suggest that such a cropping sequence can provide worthwhile results.

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- Cereal stubble protects lupins from sand blasting and brown spot disease.
- Root diseases are less common after a cereal crop than after pasture.
- Broad-leaved weeds are reduced because they are controlled in the cereal phase.
- Nitrogen build-up in clover pasture will encourage weeds in the lupin crop.
- Easier penetration in cereal stubbles allows dry or early direct drilling.
Wheat:lupins:lupins

Rotation of wheat with two consecutive years of lupins is also likely to be highly effective against brome grass (see Table 1). In a study conducted in the northern wheatbelt at East Chapman, in the cropping sequence wheat:lupins:wheat:lupins, brome grass risk appeared to be successfully removed by the fifth year of cropping. However, because of the disease risk, two consecutive years of lupins is not recommended at this stage. We hope the disease risk will be resolved through genetic manipulation and release of new disease-resistant lupin varieties.

Predicting future infestations

Using a simulation model (developed using Stella®, a software for Apple Macintosh computers), we investigated the dynamics of brome grass in lupin:wheat and lupin:wheat:wheat rotations over the long term. Results from simulation runs support our findings that brome grass densities can be reduced dramatically and maintained at low levels by the use of non-selective and selective herbicides in lupins and non-selective herbicides only in the wheat phase in a lupin:wheat rotation (see Figure 5a).

However, the change to a lupin:wheat:wheat rotation on brome grass-infested paddocks can lead to a rapid build-up in numbers of the weed, which will reduce yield severely. When effective herbicides for brome grass control in cereals become available, adoption of such rotations will become feasible. This is illustrated in Figure 5b, which shows that use of a hypothetical herbicide that gives 70 per cent brome grass control in wheat will have a major effect on the dynamics of brome grass and is expected to maintain its density at a low level.

Conclusions

Based on existing technology, maintaining brome grass at a population level of less than 10 plants per square metre is the most effective way of overcoming brome grass. This is usually achieved by the second cycle of a year-in-year-out wheat:lupin rotation and using the most effective weed control strategy.

Over two rotation cycles, an investment of between $42 to $56 per hectare in a selective grass herbicide to remove brome grass not controlled by simazine in lupin crops, can lead to a potential net return of $58 to $72 per hectare.

<table>
<thead>
<tr>
<th>Basic treatments</th>
<th>Seed bank</th>
<th>Seedling establishment</th>
<th>Seed production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lupins (simazine)</td>
<td>-69</td>
<td>+8</td>
<td>19</td>
</tr>
<tr>
<td>Lupins (simazine, Fusilade®)</td>
<td>-94</td>
<td>+0.6</td>
<td>12</td>
</tr>
<tr>
<td>Lupins (glyphosate, simazine, Fusilade®)</td>
<td>-98</td>
<td>+0.7</td>
<td>9</td>
</tr>
<tr>
<td>Pasture (no spray)</td>
<td>-78</td>
<td>+18</td>
<td>18</td>
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<tr>
<td>Pasture (spraytopped)</td>
<td>-35</td>
<td>+20</td>
<td>17</td>
</tr>
<tr>
<td>Pasture (Fusilade®)</td>
<td>-75</td>
<td>+5</td>
<td>19</td>
</tr>
<tr>
<td>Early wheat (no control of brome grass)</td>
<td>-539</td>
<td>+30</td>
<td>40</td>
</tr>
<tr>
<td>Standard wheat (1 kill of brome grass)</td>
<td>-170</td>
<td>+22</td>
<td>45</td>
</tr>
<tr>
<td>Late wheat (2 kills of brome grass)</td>
<td>-31</td>
<td>+17</td>
<td>29</td>
</tr>
</tbody>
</table>

Figure 5. Simulated dynamics of brome grass in:

(a) lupin:wheat (L-W) and lupin:wheat:wheat (L-W-W) rotations, and
(b) L-W-W rotations at varying levels of selective brome grass control in wheat.

Table 1. Annual percentage rate of decline (−) or increase (+) of brome grass seed banks, effective seedling establishment and seed production

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