BREAK CROPS AND DRY SEASONS

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Take home messages

A review of break crop experiments showed that the increased yield of wheat after a break crop was a relatively constant amount rather than a percentage increase. The yield of wheat growing in the first year after a break crop was greater than wheat after wheat by: 0.47 t/ha for oats, 0.85 t/ha for canola and 1.21 t/ha on average for the grain legumes lupin, field pea, faba bean and chickpea. The additional yield of a second wheat crop after a break crop averaged 45% of the additional yield of a first wheat crop.

Gross margins for a sequence of three wheat crops are compared with sequences of a break crop followed by two wheat crops, based on attainable yields in dry seasons in southern NSW. The calculation aims to estimate whether the additional wheat yield after break crops compensates for the relatively low returns from the break crops themselves.

- The gross margins of canola-wheat-wheat are greater than for wheat-wheat-wheat, but only when sowing the canola before mid May. Grazed canola has higher gross margins than grain-only canola when sown before early May, but sharply lower returns for later sowing.

- Grain-only wheat followed by two other wheat crops gives the highest gross margin for crops sown after late May. Grazing the first wheat crop gives higher gross margins than grain-only wheat.

- Gross margins for lupin-wheat-wheat were close to the values for wheat-wheat-wheat when the first crop was sown in late May.

Break crops

Broadleaf crops became significant parts of Australian dryland farming systems in the 1980s, starting with lupin and followed by canola in the 1990s. Experiments in the 1980s and 90s showed that much of the value of broadleaf crops was from the increased yield of the following wheat crop. A review of 135 experiments in 2001 showed that wheat after canola yielded about 20% more than wheat after wheat, and wheat after grain legumes yielded 40-50% more than wheat after wheat. For the gross margin of a canola-wheat sequence, about three-quarters of the value of a break crop was from the additional yield of the following wheat crop and only one-quarter was from the canola crop itself.

It's time to re-examine the value of break crops. The recent series of dry seasons with late starts and dry springs appeared to cause greater yield loss to broadleaf crops than cereals. Cereal root disease may be less prevalent now because of the dry springs and the cumulative effects of previous break crops. In 2008 in southern NSW, the yield of wheat after cereals exceeded wheat after broadleaf crops, apparently because cereal stubbles conserved more rainfall in the previous summer. Offsetting these disadvantages are greater appreciation of hay cut from failed canola crops, new opportunities for grazing canola and the weed control options using herbicide-tolerant canola.

Mechanisms of the break crop effect

The long recognised benefits of break crops are reducing cereal root disease and, for legumes, increasing the net supply of soil mineral N. Root diseases are suppressed because they are deprived of a host for a year. Recent research suggests that there are additional mechanisms for the break-crop effect and there is also more information about the magnitude of the break-crop effect from a review of published experiments.

We now know that the rhizobia in the nodules of legumes release hydrogen gas into the soil and that this hydrogen is taken up by other soil microbes, which stimulate the growth of the following cereal. Field experiments suggest that hydrogen released by a legume increases growth of a following cereal by at least 10% (see the paper by Mark Peoples at the 2009 GRDC updates). It is also possible that the N benefit of legumes is not only due to the additional N from biological fixation. The root residues of legumes normally have a higher C:N ratio than cereals so there is less potential for immobilisation of soil mineral N by the root residues of legumes than by cereal residues. Legumes are not the only type of crop to boost soil mineral N. There is good evidence that soil mineral N is greater after canola than after cereals, possibly because of reduced immobilisation by the root residues.

There is some evidence that part of the break-crop benefit of canola and lupin is because they are not hosts of arbuscular mycorrhizal fungi (AMF). Normally AMF colonisation in the roots of cereals growing after canola and lupin is lower than cereals growing after AMF hosts. AMF use carbohydrates from crop roots as an energy source so they are effectively parasites when they are not needed to take up the immobile nutrients P and Zn from the soil. AMF are more likely to be beneficial in soils with low P and Zn levels.

Magnitude of the break crop effect

A recent review of break crop experiments shows that the previous conclusions about a percentage yield increase from break crops is inaccurate. It is more correct to express the increase as an absolute amount than a percentage. In other words the increase is relatively constant over a range of wheat yields. A more complete discussion is available on the web (www.regional.org.au/au/asa/2008/concurrent/rotations/5786_angusjf.htm). The absolute yield increase is best shown in Fig. 1a where the yield of wheat after oats averaged 0.47 t/ha more than wheat after wheat in 113 experiments. It is known that oats are a non-host of the take-all pathogen but that they share several other root diseases with wheat.

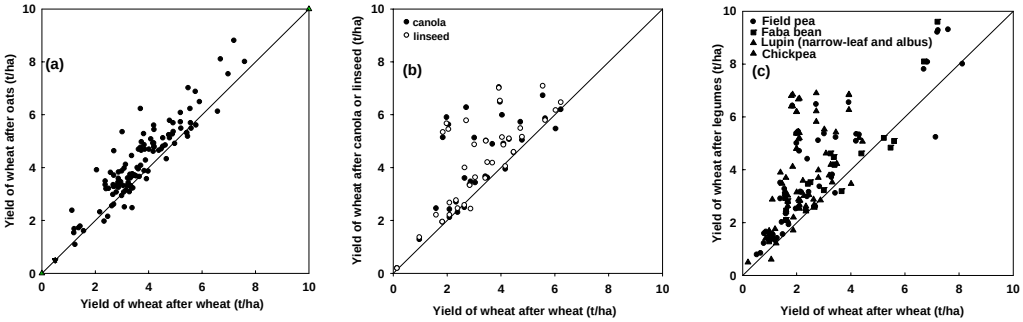

Fig. 1. Yield of wheat after break crops compared with wheat after wheat, based on a survey of published experiments. Each data point represents mean yields in replicated experiments. (a) oats (b) canola and linseed (c) grain legumes.

Based on 35 experiments, wheat after canola yielded 0.85 t/ha more than wheat after wheat (Fig. 1b). Canola breaks the life cycle of most root pathogens of wheat, so the additional yield of wheat after canola compared to wheat after oats provides an estimate of the effect of these other pathogens on wheat yield. Fig. 1b also shows the effect of linseed on wheat yield. Linseed is similar to canola in not hosting cereal pathogens but linseed is a host of AMF, while canola is not. In Fig. 1b there was no difference between the average break-crop benefits of canola and linseed. This result suggests that suppression of AMF by a single non-host does not contribute to increased yield of a following crop.

The grain legumes lupin, field pea, faba bean and chickpea increased yield of the following wheat crops, on average, by 1.21 t/ha over 98 experiments (Fig. 1b). The increase varied from 1.81 t/ha after lupin to 1.10 t/ha after field pea. The low value for field pea may reflect the dry regions where many of the experiments were conducted. The yield responses are much greater than for oats or oilseeds, reflecting the combined disease break, additional residual nitrogen and growth stimulation by hydrogen gas released into the rhizosphere.

Putting together the yield responses of wheat to previous crops we can estimate the contributions of different processes which can be added where appropriate, for example adding disease control to the other benefits of legumes (Table 1). The yield benefit from take-all suppression is estimated from the oats data and the suppression of other root diseases from the additional yield after canola. An additional contribution is assumed for stimulation of N mineralisation by canola. Estimates of the yield effect of hydrogen fertilisation by legumes vary from 0 to 15% and we have assumed a value of 10%. There is little hard evidence for a yield benefit from AMF-suppression after a single break crop, but a small benefit is included because of previous evidence from double break crops and the extraordinarily high yield of wheat after lupin, a non-host of AMF. The N benefit from legumes is estimated as the residual needed to explain the average break-crop effect shown in Figure 1.

Table 1. Contributions of different processes to the break-crop effect for a 4 t/ha wheat crop.

Process	Additional wheat yield (t/ha)
Take-all suppression	0.5
Suppression of other root diseases	0.3
Net nitrogen benefit of canola	0.1
Hydrogen fertilisation by legumes	0.4 ?
Suppression of AMF by non-host crops	0-0.1
Net nitrogen benefit of legumes	0.5

Table 1 applies to relatively moist growing seasons but do not apply when water supply is insufficient for wheat crops to express the additional yield after break crops.

Canola yield versus wheat yield

Based on the energy content of the seeds, the highest canola yield is expected to be about 60% of wheat yield. Fig. 2 shows wheat and canola yields from experiments where most

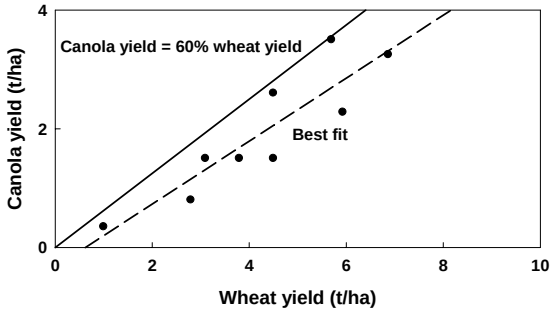

Fig. 2. Canola yields compared with wheat yields in the same experiments in southern NSW.

of the yield variation was due to water supply. In high-yielding environments, canola yield approached 60% of wheat yield but canola yields dropped faster than wheat yields in low-yielding environments. Based on the line of best fit through the data, canola yield is expected to be 42% of a 3 t/ha wheat crop, 36% of a 2 t/ha wheat crop and 20% of a 1 t/ha wheat crop.

Second wheat crop after a break crop

Thirty experiments in the dataset include comparisons of two wheat crops after a break crop, compared with two wheat crops after wheat. In these experiments the break crops included canola, Indian mustard, Linola, field pea, chickpea and oats. There were not enough measurements to distinguish between the second-year break crop effects between species so the results are combined.

The additional yield for the first wheat crop after a break crop was 0.41 t/ha and for the second wheat crop was 0.19 t/ha. Compared with the larger datasets reported earlier, this dataset underestimates the effect of a break crop on the first wheat crop so it probably also underestimates the effect on a second wheat crop. In the following gross margin analysis the effect of a break crop on the second wheat crop is estimated to be 45% of the effect on the first wheat crop.

Gross margins

Fig. 3 shows gross margins estimated for 3-year crop sequences, using 2009 prices and variable costs. Each 3-year system consists of a break crop (or wheat as a control) in year 1 followed by two years of wheat, with yields modified by the relationships shown in Fig. 1. Each line represents different sowing dates for the first crop, followed by a standard sowing date for the following two grain-only wheat crops.

The assumed maximum wheat yield is 4 t/ha, reflecting the low yields since 2001. The yield of canola relative to wheat is as shown by the line of best fit in Fig. 2. Yields are assumed to decrease with delayed sowing by 4% per week for cereals and 8% per week for broadleaf and grazed crops. The assumed sowing dates for grazing and broadleaf crops are 14 days before sowing grain-only wheat. The livestock returns from grazing wheat and canola are as reported in recent experiments.

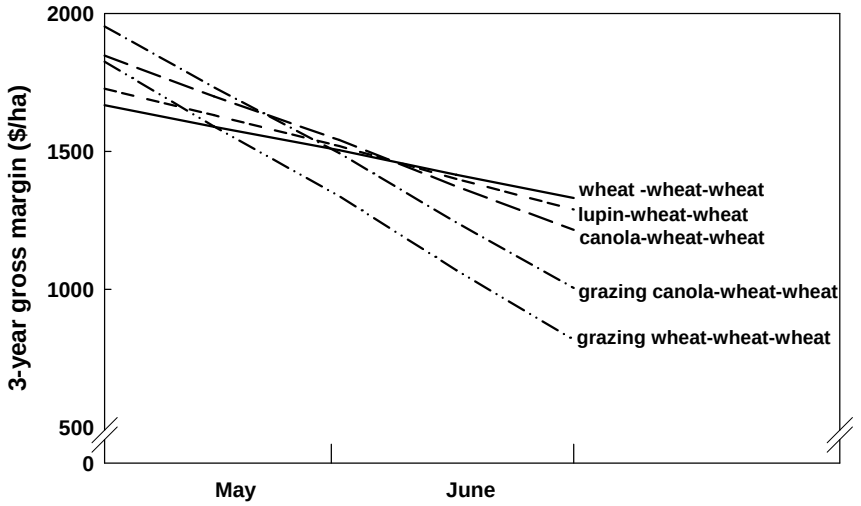

Fig. 3. Estimated gross margins for 3 years of crops in relation to sowing date in year 1. The assumed sowing date of broad-leaf crops and grazed crops is 14 days before the sowing date of wheat.

The highest gross margins estimated by this approach are when grazing canola is grown in year 1, provided it is sown by early May. The next highest gross margin is when grain-only canola is sown in year 1, provided it is sown by mid May. Grazing wheat also has high gross margins for early sown crops, but, as with grazing canola, delayed sowing reduces the 3-year gross margin more sharply than grain-only crops. The gross margins for early-sown grazing canola and grazing wheat are high because of the additional returns from livestock, but the calculation is based on the assumption that grain yield is not affected by grazing.

If canola is not sown by mid May, the 3-year gross margin for wheat-wheat-wheat is slightly higher than for canola-wheat-wheat. If sowing is delayed after late May the advantage of a first wheat crop becomes progressively greater than a first canola crop. This is because the break-crop benefit of canola is not large enough to offset the low returns from the canola crop itself.

Lupin-wheat-wheat also gives high gross margins for early sown lupin crops because the large break-crop effect compensates for the relatively low returns from the lupin itself. However the lupin-wheat-wheat result depends on adequate water supply to support the high yield potential of the following wheat crops.

The results of this approach apply to dry growing seasons. They may even overestimate the value of break crops because they do not account for the apparently poor retention of summer rain by the light stubbles of break crops and the low incidence of cereal root disease in dry seasons. These are grounds for restricting the area of break crops in dry seasons. Reasons for persisting with some break crops are control of herbicide-resistant weeds and the hope of capturing their benefits in wetter seasons.

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