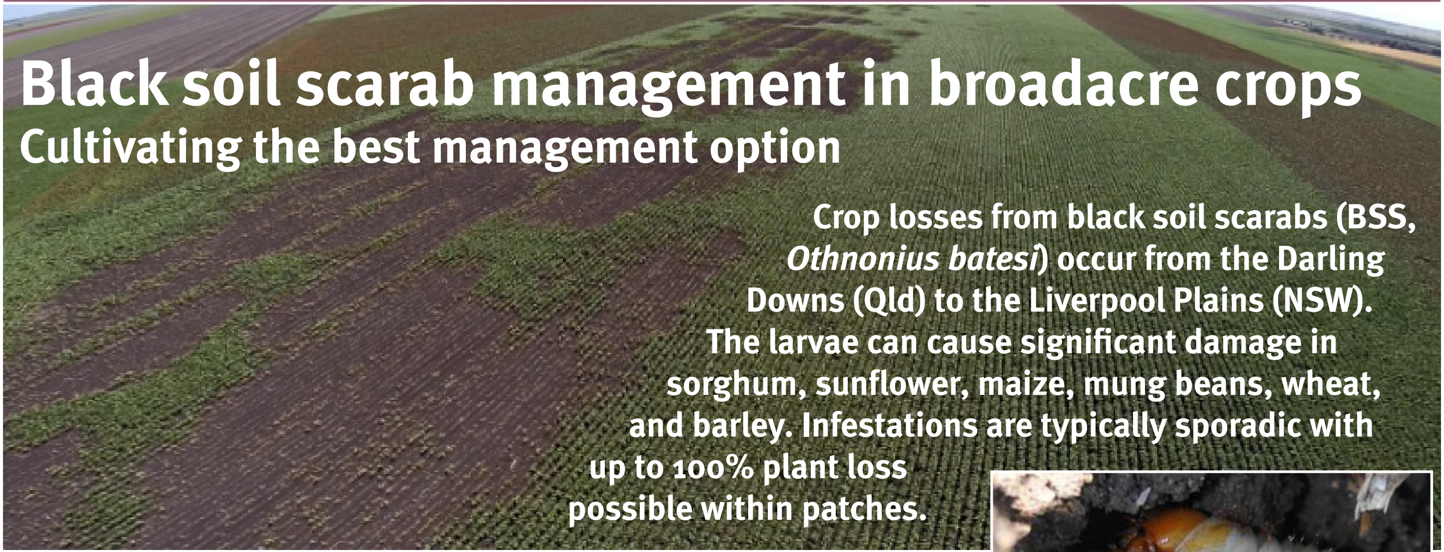

Black soil scarab management in broadacre crops

Cultivating the best management option

Crop losses from black soil scarabs (BSS, *Othnonius batesi*) occur from the Darling Downs (Qld) to the Liverpool Plains (NSW). The larvae can cause significant damage in sorghum, sunflower, maize, mung beans, wheat, and barley. Infestations are typically sporadic with up to 100% plant loss possible within patches.

Black soil scarab (BSS) feeding on the roots reduces the plant's ability to survive periods of moisture stress, with greater impacts in dry, hot seasons. There are currently no in-crop options for control, and chemical treatments at planting are unlikely to provide sufficient residual impact to successfully manage this pest.

Adult females are flightless, therefore infestations build within the field over successive seasons, providing an opportunity to implement control between crops. The lack of chemical registrations for BSS and difficulty accessing larvae limits current control options to cultivation, either targeting individual patches or applied across the whole paddock.

Cultivation as a management tool

Minimum and zero till systems have greatly improved water use efficiency and yields in broadacre cropping. Maintaining stubble cover assists infiltration and soil moisture storage and reduces runoff, and therefore there is reluctance by many to undertake any cultivation, but these benefits must be weighed up against the chance of no yield within BSS-affected patches. Strategic cultivation may also be beneficial in improving subsoil constraints and allowing the deep placement of nutrients.

The best time to cultivate is post harvest before a long-fallow when the field has minimum soil moisture, and there is sufficient time to capture and store rainfall. Targeted cultivation should focus on the plant row (where the majority of larvae are usually found), and prioritise patches with the highest population densities.

Damage from BSS does not occur every year and the triggers and influencing factors are not well understood. Therefore BSS management is challenging, and decisions need to be based on the probability of future crops incurring BSS damage. This fact sheet looks at a typical six year rotation and the economic implications of damage when cultivation is used as a preemptive control measure.

Case study: net benefit of cultivation options in a six year rotation

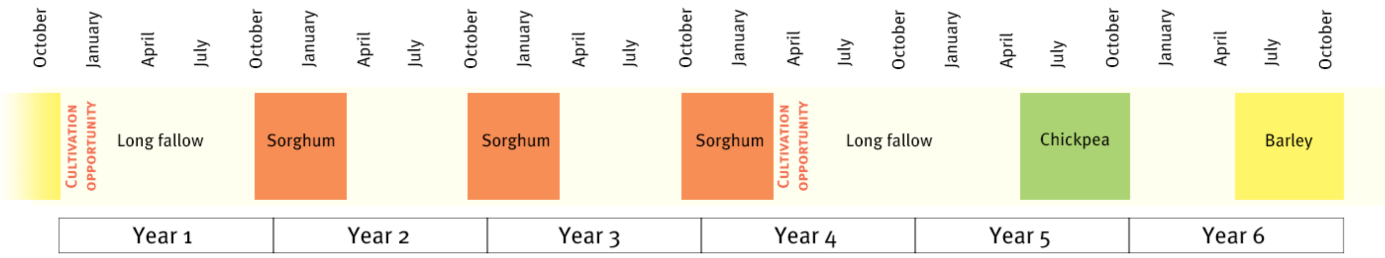

Figure 1. The example six year rotation used in this case study. It includes five crops, two long fallows and three short fallows.

This case study is based on a typical northern region summer dominant, 6-year crop rotation of sorghum, chickpea, and barley (Figure 1). To evaluate the benefits and risks of cultivation for the management of BSS, we investigated two cultivation options:

a. a single cultivation at the start of the first long-fallow within the 6-year rotation; and
b. cultivation at the beginning of each long fallow (i.e. 2 cultivations within a 6-year rotation).

Although the BSS population persists over time, crop damage does not occur every year, so we examined the average impacts of yield damage occurring once (1x), twice (2x) or three times (3x) within the rotation.

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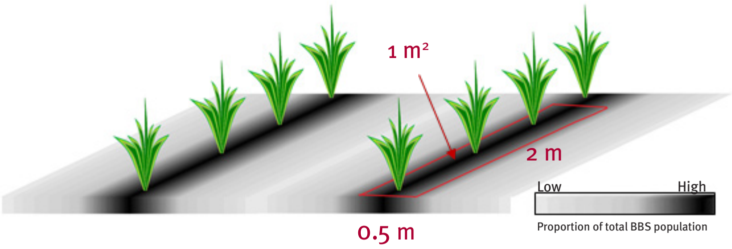
Case study assumptions

With limited information available about the population dynamics, control efficacy, and impacts of BSS on different crops, we used knowledge and experience from entomologists, agronomists and growers to estimate some parameters. Note that BSS populations are usually concentrated within 25 cm either side of the crop row, so population density per m² is based on sampling two metres of crop row (2 m x 0.5 m).



Pest densities and population growth

- Infestation starts with 20% of a field (2000 m²/ha).
- The area infested increases by 5% per year.
- After the control event, the BSS population will not increase until the next planting.
- Populations converge to the general equilibrium 35 BSS/m² (Figure 2).
- A single cultivation event to 10-15 cm deep achieves a 60% reduction in BBS populations[1].

Impact on yield and costs

- Potential crop damage as BBS population levels increase is estimated in Figure 3
- Crop yields and prices used in this case study are provided in Table 1.
- Cultivation costs $30/ha (regardless of proportion of the hectare cultivated).

1 Trials on the Darling Downs indicated that cultivation using offset disc or chisel plough reduced BSS densities by 70-80%. This case study uses a more conservative efficacy of 60% control.

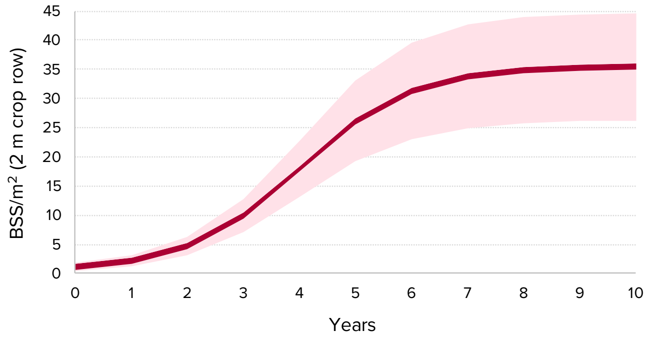


Figure 2. Estimate of average BSS population growth over time before reaching the general equilibrium position of 35/m². The shaded area denotes the potential range of values.

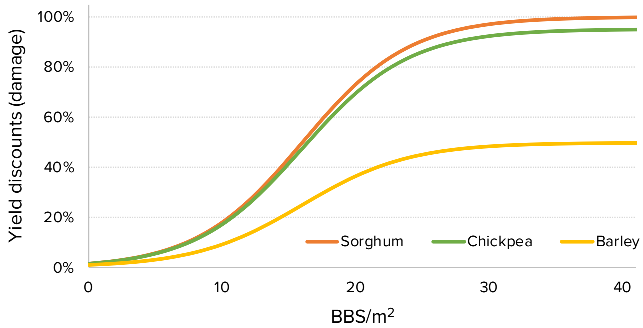


Figure 3. Potential yield losses for a range of BSS populations and crops.

Table 1. Expected crop yields and prices.

Crop	Yield (t/ha)	Price ($/t)	Potential income ($/ha)
Barley (B)	4.0	218	872
Chickpea (Ch)	2.5	504	1255
Sorghum (S)	5.0	221	1105

Impact of cultivation on populations

After the initial cultivation, the BSS population drops to 14 BSS/m², then increases over time towards the general equilibrium position, reaching around 30 BSS/m² by the end of the third sorghum crop and the general equilibrium position by the end of the crop rotation (Figure 4). A second cultivation prior to the long fallow in year 3 can reduce the BSS population to 12 BSS/m², providing a benefit to the chickpea and barley crops, and more importantly result in a BSS population of about 20 BSS/m² at the end of the 6-year cycle. A further cultivation prior to the next rotation could reduce the population to 8 BSS/m².

Figure 4. Population impact for one and two cultivations per rotation, shown over two consecutive rotations.

Economic impacts of management options

A number of variables affect the net economic benefit of managing BSS with cultivation, including the number of damage events, the initial population density (BSS/m²), cultivation efficacy, and the initial size of the infested area. Each of these were investigated independently to assess the economic outcomes.

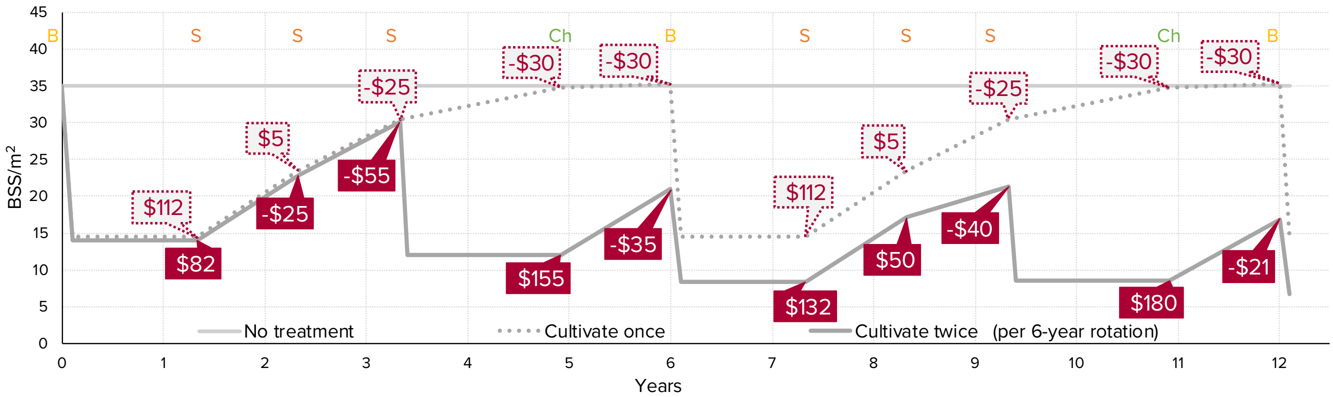


Figure 5. Economic benefit (call-out boxes) for one and two cultivations per rotation for a single event occurring in the respective crop, shown over two consecutive rotations. The cultivate twice strategy values includes both cultivation costs. Note that the greatest economic benefits occur in the crops directly after the cultivation events.

1. Number of damage events

a. Damage occurs once per rotation

The dollar values in Figure 5 represent the net benefit if BSS yield damage happens in that crop under the single cultivation and two cultivations per rotation options. For example, if BSS yield damage was to occur in the first sorghum crop the net benefit would be $112/ha with the single cultivation regime. If the BSS damage occurred in the second sorghum crop the benefit decreases to $5/ha due to BSS population growth. The single cultivation benefits of reduced BSS completely dissipate by the chickpea crop (~5 years). For the two-cultivation regime, the net benefits are lower for the initial sorghum crop due the averaged costs of the additional cultivation. However this is more than offset by the possible benefits in the chickpea crop. Net benefit is lower if the damage occurs in the barley crop as it is not as susceptible to BSS.

Because the affected crop is an unknown variable, an average over the rotation was used; the net benefit of a single cultivation and a single BSS event (1x) within a rotation is $6.40/ha ($112 + $5 - $25 - $30 - $30 / 5 crops) or $1.07/ha per year ($6.40 / 6 years). For the two cultivation regime, the average net benefit from a single BSS event (1x) is $24.62/ha ($82-$25-$55+$155-$35/5 crops) or $4.10/ha/year.

b. Damage occurs more than once per rotation

The results of two (2x) and three (3x) occurrence of BSS events with both cultivation regimes are given in Table 2. There are also additional benefits with the two-cultivation regime in the second rotation, with lower BSS populations and higher net benefits for all crops.

c. Damage does not occur in this rotation

Even if no loss from BSS yield loss (0x) occurred within the rotation, the worst case is a net loss of $30/ha ($5/ha/year) and $60/ha ($10/ha/year) for the single and double cultivation management strategies respectively. However, with the two cultivation strategy the BSS population is much lower, potentially leading to benefits in following crop rotations.

2. Initial BSS population densities

Keeping populations below about 10 BSS/m² avoids high yield losses (Figure 3) and provides higher net benefits over multiple crops within a rotation. However any cultivation benefit rapidly declines as populations fall below 5 BSS/m² (Figure 6). Over the 6-year crop rotation, the average annual net benefits from two cultivations per rotation were approximately double that of the single cultivation treatment.

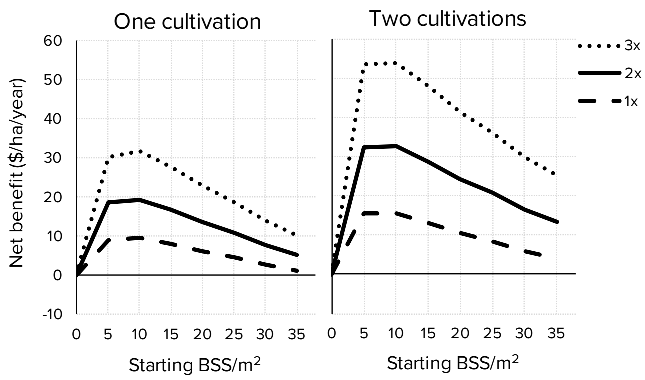


Figure 6. Net benefit of cultivation ($/ha/year) for a range of population densities.

Table 2. Average net benefit ($/ha) of cultivating once or twice per 6-year rotation, taking into consideration potential yield loss events.

	1 cultivation per rotation				2 cultivations per rotation			
Damage occurrence per rotation	0x	1x	2x	3x	0x	1x	2x	3x
Average benefit per rotation ($/ha)	-30	7	31	62	-60	24	81	152
Average benefit per year ($/ha)	-5.00	1.12	5.20	10.30	-10.00	4.10	13.51	25.27

3. Treatment efficacy

In theory, as BSS control efficacy increases, the economic benefit also increases, however it is not possible to eradicate BSS (an efficacy of 100%) with cultivation, and even if it were then the economic benefits would be beyond a 6-year crop rotation. Based on this case study, for the single cultivation to be economically viable, the kill rate needs to be greater than 40% if BSS losses occur three times (3x) or 60% if BSS losses occurs once (1x) within the 6-year rotation (Figure 7). Two-cultivation treatments efficacy requirements decrease to 35% and 50% respectively. With the two-cultivations treatment, there is a near linear relationship between increased control efficacy and net annual financial benefits, above the break-even point ($0/ha/year). Under all these scenarios, there is no economic benefits when efficacy is below 40%, and greater than 60% efficacy will result in economic benefits in most cases.

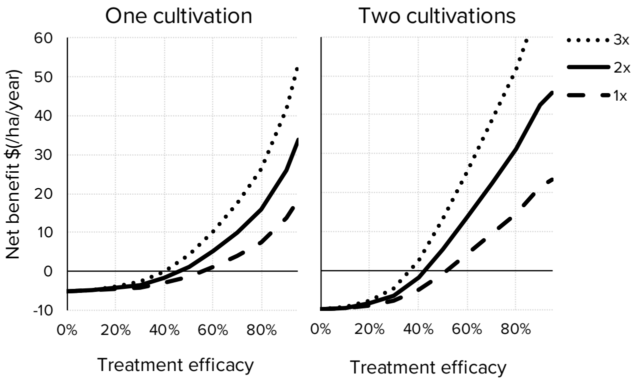


Figure 7. Net benefit of cultivation ($/ha/year) for a range of treatment efficacies.

4. Area of infestation

The area infected by BSS affects the economic outcomes, control can be uneconomical in small areas. Under both cultivation regimes, treating an infested areas under 500 m² or 5% of a hectare is unlikely to be economically viable (Figure 8). When more than 20% of the area is infested then cultivation will result in economic benefits in most cases. As the area infested increases, there are higher expected economic benefits from the two cultivation regime.

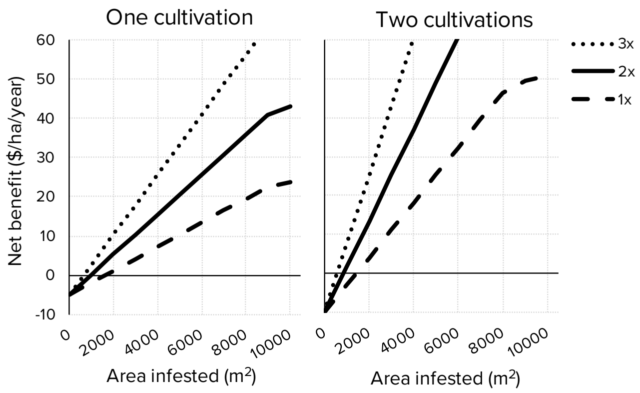


Figure 8. Net benefit of cultivation ($/ha/year) for a range of infested areas.

Last revised June 2020

Key findings

1. Avoid planting more than three successive sorghum crops, as the initial cultivation has minimal impact after the third year.
2. Cultivation efficacy needs to be greater than 60% to be economically viable; higher efficacies will generate higher economic benefit.
3. When the BSS infested area is less than 5% it is not economically viable to treat with cultivation; when greater than 20% then there is a high likelihood of economic benefits. The two-cultivation regime offers higher economic returns for larger infested areas.
4. An estimated population density threshold is 5 BSS/m². Only cultivate affected areas; this may reduce cultivation expenses and maintain the benefits of no-till in unaffected areas.

Considerations

1. Due to BSS population growth, a cultivation will only affect the population for about 4 years. Therefore, more regular cultivation within a crop rotation at the beginning of the long fallows reduces the risk of economic losses.
2. The economic benefits of treating BSS come from the crop directly after cultivation treatments.
3. If BSS populations are above the threshold, cultivating infested areas within the paddock at the beginning of each long-fallow will on average result in twice the economic benefit of a single cultivation.
4. If BBS are above threshold but there were no damage events during the rotation, the greatest economic loss is the cost of two-cultivations ($10/ha/year). However this cultivation would still reduce the underlying BSS population densities resulting in future economic benefits.
5. If BSS yield losses occurred in the second sorghum crop and BSS populations are high and the infested area is more than 20%, it may be advantageous to consider cultivating post-harvest and go into a long-fallow phase before a chickpea crop.

Acknowledgments

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