Banding mill by-products – representative economic analysis, Burdekin region

2016

Acknowledgements:

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Summary

While the application of mud can provide soil health benefits, banding mud directly on the cane row helps to reduce application costs and may decrease the risk of nutrient runoff. A fundamental question underlying the trial is whether banding mud, broadcasting mud or conventionally spreading mud at lower application rates can maintain or improve grower profitability relative to the common industry practice of conventionally spreading mud at 200 tonnes per hectare (t/ha). Four commercial farms are analysed in detail to establish a range that might be indicative of the economic implications for similar farms in the broader Lower Burdekin region. In particular, the report investigates:

(1) The main cost drivers and the associated cost savings when applying mud;
(2) The yield improvements needed by each mud treatment to break-even economically with the no mud treatment;
(3) Harvest results from the trial sites to compare the gross margin for each treatment and the cane yield improvements still needed in future crops.

When comparing all the cost differences at one of the trial sites located 50 kilometres from the mill (mud cartage, fertiliser and cultivation expenses), banding mud at 65t/ha costs around $750 per hectare ($/ha) less than spreading mud conventionally at 200t/ha. However, this difference was much lower at the sites closer to the mill, where cost savings ranged between $105 and $240/ha. Interestingly, the banded mud treatment at two of these sites can have lower overall costs than applying no mud at all; due to relatively low mud cartage costs compared to the potential savings in fertiliser costs.

At the site located a long distance from the mill, conventionally spreading mud at 200t/ha was found to require a total cane yield improvement of just over 25 tonnes of cane per hectare (TCH) to break-even with the no mud treatment (inclusive of fertiliser cost savings), compared to just 2.7 TCH for the 65t/ha banded treatment. In contrast, the break-even cane yield for the 200t/ha conventionally spread treatment at those sites located within close proximity to the mill were much lower; ranging between 5 and 10 TCH. Nevertheless, the 65t/ha banded mud treatments at these sites were not found to require a yield improvement.

Results from the analysis, using 2015 harvest data, highlight the potential for farms located far from the mill to band mud at a lower rate onto the hill as a potentially feasible alternative to conventional applications of mud at 200t/ha. Making inferences based on the economic results from the four sites so far, there is little evidence to suggest that the 200t/ha conventionally spread treatment is more profitable than the 65t/ha banded mud treatment.

NQ DRY TROPICS FARMACIST Australian Government Queensland Government

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1 Introduction

The NQ Dry Tropics Sugarcane Innovations Programme explores innovative and aspirational practices to reduce nutrient and pesticide losses from Burdekin sugarcane farms. The programme is funded through a number of organisations including: Project Catalyst, a pioneering partnership funded by the Coca-Cola Foundation through the World Wide Fund for Nature (or WWF); the Australian Government Reef Programme GameChanger project; and the Australian Government Reef Programme through Reef Water Quality Grants that allow early adoption of practice changes to ultimately improve water quality outcomes. These projects are delivered in partnership with the Department of Agriculture and Fisheries, Farmacist, Burdekin Productivity Services and the Burdekin Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC).

A particular focus of the innovations programme is to foster the rapid uptake of innovative management practices and technologies that improve the quality of water leaving farms in order to alleviate the potential for adverse effects on the resilience of the Great Barrier Reef. It provides an opportunity for sugar cane growers to work closely with technical specialists to examine game changing management practices that may enhance productivity and profitability while improving environmental outcomes. The farm-based research trials undertaken as part of the programme highlight the associated costs and benefits of adoption, as well as practical improvements to management practices. They generate evidence-based research data and advance knowledge about the implications from adopting innovative practices. Moreover, the engagement process facilitates the communication of information by enabling participating farmers to learn and disseminate their experiences to other farmers, which serves as a catalyst to a sustainable farming future.

While the application of mill by-products (mud) can provide soil health benefits, banding mud directly on the cane row helps to reduce application costs and may decrease the risk of nutrient runoff. A fundamental question underlying the trial is whether banding mud, broadcasting mud or conventionally spreading mud, at lower application rates, can maintain or improve grower profitability relative to the common industry practice of conventionally spreading mud at 200t/ha.

In this report, four commercial farms are analysed in detail to establish a range that might be indicative of the economic implications for similar farms in the broader Lower Burdekin region. Each of the farms are located a variety of distances from local mills and have different soils and nutrient requirements, which enables the analysis to investigate the profitability of the mud treatments at a range of mud cartage prices and fertiliser cost savings. In particular, the report evaluates the main cost drivers and cost savings associated with applying mud and investigates the improvements in yield necessary to offset the costs from applying mud. Harvest results from the trial sites for 2015 are used to compare the profitability of the different treatments.

2 Banding mill by-products

The application of mud to fallow and ratoon blocks can provide a multitude of soil health benefits to sugarcane growers. Advantages may include the improvement of soil texture, structure and biology as well as supplying a range of nutrients, including nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium and some micronutrients (Benson, Royle & Holzberger, 2013). In order to maximise farm profitability it is essential to account for nutrients provided by mud when developing a nutrient management plan (Qureshi, Wegener, Qureshi, & Mason, 2002).

Mud is usually applied directly into the furrow at application rates of 200 tonnes per hectare (t/ha). As mud is a by-product of the sugar milling process, it is generally made available at a low cost. Nevertheless, sugarcane growers must transport the mud from the mill to their farms and apply it over their fields. Cartage operators normally serve this function and charge farms by the volume or tonnage hauled and distance from the mill[1] (Markley & Refalo, 2011). Accordingly, distance may be a barrier to applying mud, due to the relatively higher haulage costs associated with carting mud larger distances.

[1] To cover variable expenses associated with fuel, labour and truck maintenance.

Banding mud helps to improve the cost-effectiveness for all users as application rates can be reduced compared to conventionally applied amounts. This is particularly important for farms located long distances from the mill as it increases the affordability of mud. The placement of mud directly on the sugarcane row permits the grower to minimise tillage operations as incorporation of the product is not required. Furthermore, the mud is not exposed to irrigation water in the furrow, potentially reducing the off-site movement of nutrients.

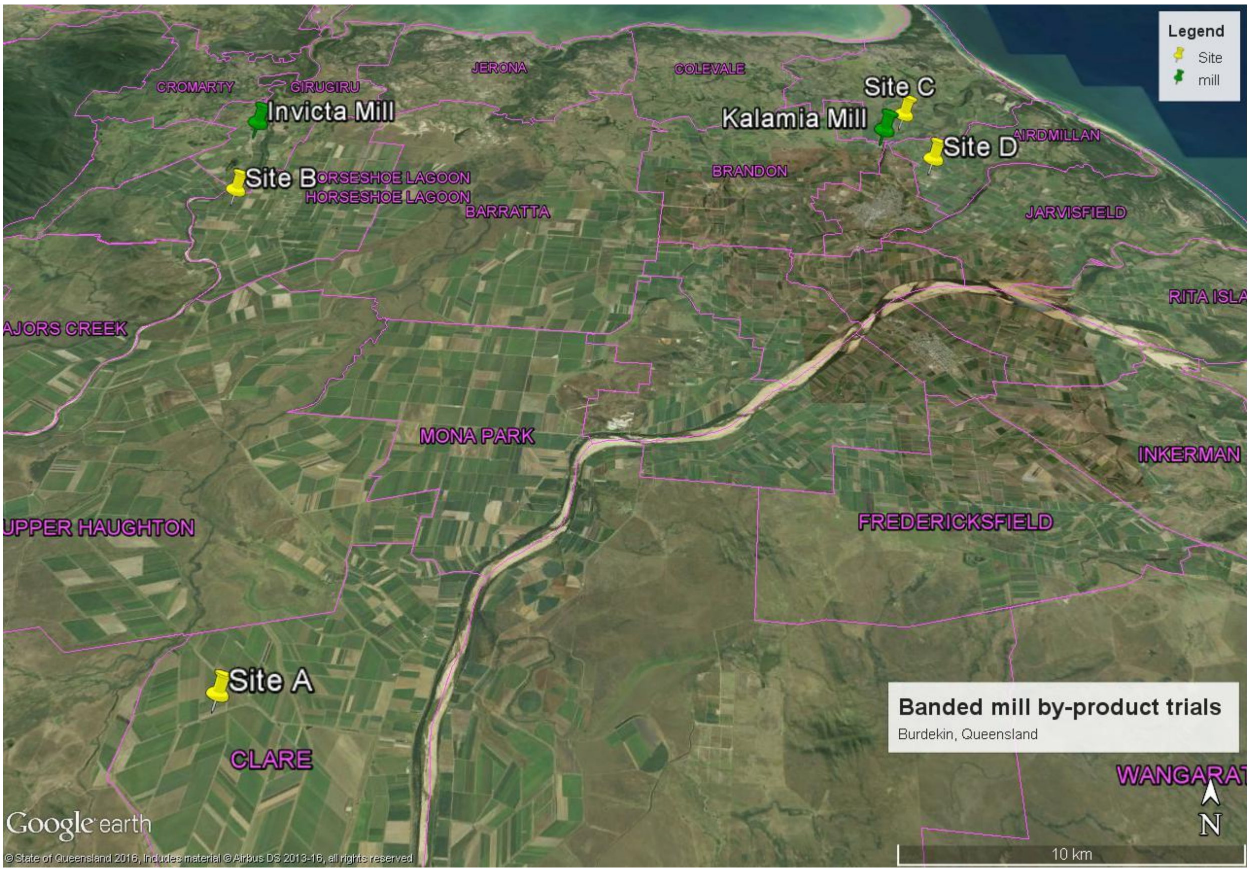
Image 1: Conventionally spread mud (left) and banded mud (right).

Source: Farmacist, 2014

3 Burdekin trials

Farmacist established four different trial sites during 2014 on crops entering various ratoon classes. Image 2 shows the locations of the trial sites in the Lower Burdekin region.

Image 2: Trial site locations.



The following subsections provide a description of the trial sites and their corresponding trial designs.

3.1 Trial site characteristics

The economic evaluation draws upon trial site information from four commercial Lower Burdekin sugarcane farmers that are participating in mud trials as a part of the Sugarcane Innovations Programme. Table 1 lists some of the key characteristics of each trial site. The analysis utilises specific farm operational information to determine the feasibility of applying mud using a range of methods and application rates.

Table 1: Characteristics of trial sites.

Element	*Site A*	*Site B*	*Site C*	*Site D*
Soil type:	Clay, sodic subsoils	Sandy Loam	Loam	Clay Loam
Location:	Mulgrave, BHWSS[2]	Giru, BHWSS	Kalamia, Delta	Ayr, Delta
Fertiliser:	Granular (stool split)	Liquid (stool split)	Dunder (stool split)	Granular (stool split)
Crop cycle:	4 ratoons	2 ratoons	4 ratoons	5 ratoons
Row spacing:	1.65m	1.8m duals	1.52m	1.6m

3.2 Trial designs

The fundamental question underlying the trials is whether banding mud, or conventionally spreading mud, at lower application rates can maintain or improve grower profitability relative to the common industry practice of conventionally spreading mud at 200 tonnes per hectare (t/ha). Consequently, the four trial sites were set-up to compare common practice with banded treatments and conventionally spread treatments at lower rates, and control treatments with zero mud.

Table 2 outlines the mud application methods and rates for the different mud treatments being examined on each trial site. On every site, mud was spread conventionally at two different rates (1) 200t/ha, and (2) 100t/ha. On three of the sites (A, B and C), mud was banded at 65 t/ha over the stool, while for Site D mud was banded at 120t/ha over the stool. Site C also has a broadcast treatment where mud has been broadcasted[3] over the field at 35t/ha using a purpose-built implement. In addition, a zero mud treatment is being examined on all trial sites. All treatments were replicated and randomised except for the broadcast treatment at Site C.

Table 2: Mud application methods and rates at each trial site.

Treatment abbreviation	**Placement**	**Mud application rate (t/ha)**			
		Site A	*Site B*	*Site C*	*Site D*
No mud*	n/a	0	0	0	0
200t/ha conv.	Conventionally spread – into the furrow	200	200	200	200
100t/ha conv.	Conventionally spread – into the furrow	100	100	100	100
120t/ha band.	Banded – over the stool	-	-	-	120
65t/ha band.	Banded – over the stool	65	65	65	-
35t/ha broad.	Broadcast – over the furrow and stool	-	-	35	-

* Control scenario

[2] Located within the Burdekin-Haughton Water Supply Scheme (BHWSS) zone.
[3] The purpose-built broadcast mud spreader casts mud over up to nine rows at once, spreading mud thinly over both the row and interrow.

Table 3 outlines the sugarcane crop class that each trial was established in (i.e. first ratoon). Each trial was established during 2014 with replicated treatments. Accordingly, the first production results from the trials were harvested in 2015.

Table 3: Crop class that each trial was established in.

	Site A	*Site B*	*Site C*	*Site D*
Crop class (trial establishment)	2nd ratoon	1st ratoon	3rd ratoon	1st ratoon

4 Methodology and parameters

The economic analysis compares the profitability of the different mud treatments at the block level[4] on the four farm sites. Three key research questions are examined in this study:

(1) What are the main cost drivers and the associated cost savings when applying mud?
(2) What are the cane yield improvements needed by each mud treatment to break-even economically with the no mud treatment?
(3) Using the harvest results from the trial sites, how does the gross margin for each treatment compare and what are the cane yield improvements still needed in future crops?

The first question examines the costs associated with conventionally spread, banded and broadcast mud applications for four commercial farms. The main cost differences include mud cartage costs, fertiliser costs and cultivation expenses. As mud is applied around the same time as fertiliser, application costs are added to the respective year's growing costs/cash flows instead of being accounted for as a capital expense. Nevertheless, the application of mud can provide monetary benefits over several years since potentially less P and N needs to be applied as fertiliser during later crop classes. Accordingly, these monetary benefits from future years are discounted to present value and accumulated with cash flows over a complete crop cycle to effectively compare the performance of each mud treatment.

For one trial site, mud cartage costs are considerable due to the farm's proximity to their local sugar mill (up to ~50 kilometres). Consequently, the second research question investigates how much extra cane needs to be grown to offset these costs in order for each mud treatment to break-even with the zero mud treatment. For each break-even yield analysis, trial production data is used to calculate revenue for the no mud treatment, while past production data from the trial block is used to approximate future ratoon yields. Table 4 shows the production estimates for the no mud treatment– cane yield (TCH) and commercial cane sugar (CCS). The highlighted yields indicate the beginning of the trial (the crop class when the mud was spread) and shows the first year of harvest results for the no mud treatment in each trial.

Table 4: Production figures used for the break-even analysis.

	Site A		**Site B**		**Site C**		**Site D**	
	TCH	*CCS*	*TCH*	*CCS*	*TCH*	*CCS*	*TCH*	*CCS*
Plant	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1st ratoon	n/a	n/a	78	14.8	n/a	n/a	148	13
2nd ratoon	118	15.5	110	15.1	n/a	n/a	155	13
3rd ratoon	115	14.7	-	-	127	15.7	138	14.1
4th ratoon	88	14.4	-	-	120	14.7	130	13.2
5th ratoon	-	-	-	-	-	-	89	15.5

[4] The economic analysis examines the investment into mud at the block level (instead of assuming steady state with a whole-of-farm analysis) given that a farmer may not routinely apply mud to every block.

As banding mud is relatively new to the Burdekin, the prices sourced from local cartage operators may be subject to change over time[5]. To take these possible price variations into account, the yield improvement required for the banded mud treatment to break-even with the zero mud treatment is examined at a range of prices.

The third question explores how the mud treatments have performed so far. The analysis draws on 2015 harvest data from the sites to calculate and compare the gross margins for each treatment. In addition, the analysis investigates what improvements are still needed in future ratoon crops for the mud treatments to break-even with the no mud treatment.

The Farm Economic Analysis Tool (FEAT) was used to undertake a comprehensive evaluation of the implied revenues and costs of each mud scenario. A FEAT analysis requires the sugarcane grower to provide detailed information regarding their production system (e.g. fertilising, machinery operations, irrigation). From these results, the gross margin for each mud treatment is compared, which is calculated by taking the revenue received from the crop and subtracting variable growing expenses[6]. The analysis uses a discount rate[7] of seven per cent and the five-year average net sugar price[8] of $430/t. Input prices (e.g. fertilisers and cartage) were collected from local suppliers in 2015.

5 Results

The results of the economic analyses are divided into three sections. Firstly, the mud cartage, fertiliser and cultivation expenses associated with conventionally spread, banded and broadcast mud applications are evaluated. This is followed by an investigation into how much extra cane needs to be grown to offset these costs for each of the mud treatments to break-even economically with the zero mud treatment. The final section draws on harvest data to compare how each mud treatment performed during the first growing season, after the mud was applied.

5.1 Mud cartage, fertiliser and cultivation expenses

The following subsections evaluate the key cost differences between conventionally spread, banded and broadcast mud applications, which are mud cartage costs, potential fertiliser cost savings and cultivation expenses.

5.1.1 Mud cartage costs

Table 5 outlines the mud cartage and application costs for each of the mud scenarios. These costs were found to vary between $109 and $1,200 per hectare depending on the particular trial site's distance from the mill, the quantity of mud being carted and, in most cases, the method used to spread the mud in the paddock (e.g. conventionally or banded).

Table 5: Mud cartage and application costs for each scenario.

	Site A	Site B	Site C	Site D
200t/ha conv.	$1,200	$600	$284	$284
100t/ha conv.	$600	$300	$142	$142
120t/ha band.	-	-	-	$201
65t/ha band.	$390	$228	$109	-
35t/ha broad	-	-	$166	-

[5] Moving into the future, the price will likely be dependent on the rate of adoption by sugarcane growers as well as the changes in operating costs and revenues incurred/accrued by cartage operators from banding mud instead of applying it conventionally.

[6] Variable growing expenses include fertiliser, chemical, irrigation, machinery and harvesting costs.
[7] Determining the differences in profitability between the mud treatments involves calculating the expected change to cash flows over the period of time that mud provides monetary benefits and then discounting each of these future values so they are expressed in today's dollar terms.
[8] Using net sugar prices from QSL's seasonal and harvest pools in 2010-14 (Queensland Sugar Limited, 2015).

5.1.2 Nutrients supplied by mill by-products and potential fertiliser cost savings

Sites A and B received mud from the Invicta Mill, while sites C and D received mud from Kalamia Mill. One mud sample from each mill was taken so laboratory analyses could be undertaken to identify the nutrient content of the mud samples (mill by-product contained both mud and ash). To get an indication of the N, P, K and S supplied by each mud treatment, Table 6 shows the nutrient composition of the mud at the time of analysis multiplied by the mud application rates for each treatment.

Notably, the N quantities identified by the analysis do not take into account the total N supplied by mud over time (N supplied by mud is gradually released). The Six Easy Steps nutrient guidelines for the Burdekin recommend reducing N rates by up to 100kg N/ha depending on the type of mill by-product applied and the amount of time passed since application (Sugar Research Australia, 2013).

Table 6: Nutrient composition of mud at time of analysis multiplied by application rate (kg/ha).

	Invicta mill - sites A and B				Kalamia mill - sites C and D			
	N	*P*	*K*	*S*	*N*	*P*	*K*	*S*
200t/ha conv.	<1	420	260	66	<1	1340	340	44
100t/ha conv.	<1	210	130	33	<1	670	170	22
120t/ha banded	-	-	-	-	<1	804	204	26
65t/ha banded	<1	137	85	21	<1	436	110	14
35t/ha broad.	-	-	-	-	<1	235	60	8

After applying mud, farmers have the option to adjust their fertiliser rates to account for the nutrients provided by the mud and save on fertiliser costs. Consequently, the economic analysis examines two different scenarios. The first scenario assumes that fertiliser rates are adjusted to account for the nutrients provided by mud, while the second scenario assumes no fertiliser cost savings.

Put simply, if the farmer at Site A was able to reduce their fertiliser usage by the total quantity of nutrients initially supplied by the 200t/ha mud treatment then they could potentially save around $1,700/ha (when substituting with cost effective granular fertiliser products[9] - excluding calcium, micronutrients, etc.). However, it is not accurate to calculate fertiliser savings this way. For example, the farmer cannot save what they would not actually apply in fertiliser[10] and there are uncertainties surrounding the availability of nutrients to subsequent sugarcane crops (e.g. placement and movement of nutrients out of the root zone, time of uptake by subsequent crops). To gauge crop uptake, Table 7 provides an estimate of the average quantity of N, P, K and S removed by a cane crop in the Burdekin (Calcino, Kingston & Haysom, 2000).

Table 7: Nutrients removed per cane crop – average.

	N	P	K	S
Nutrients removed (kg/ha/crop)	154	37	276	25

This analysis uses a conservative approach to calculate fertiliser savings. For instance, as it is essential to conduct soil tests at the beginning of a crop cycle to identify the soil nutrient balance, only nutrients likely to be consumed by the following ratoon crops are included. Because sugarcane is a luxury feeder[11] of K, and S is highly mobile in the soil, only the quantities of these elements that are likely to be consumed within the first year after application are included. Importantly, fertiliser savings

[9] Urea, Di-Ammonium Phosphate, Muriate of Potash and Sulphate of Ammonia.
[10] Importantly, costing additional nutrients that are not normally applied would be double counting given that yield improvements are taken into account in the economic analysis.
[11] Luxury feeding refers to the crop continuing its intake of a nutrient in excess of the optimal amount (recommended application rate) without providing any agronomic/physiological benefits.

have been calculated based on the respective grower's general fertiliser usage. Consequently, if the grower does not normally apply any P, K or S in their ratoon crops, then the potential fertiliser cost savings from not having to apply these nutrients are assumed to be zero.

Based on the guidelines mentioned above, the total prospective reductions in fertiliser applied nutrients over the ratoon crops for the different mud treatments are depicted in Table 8 for each site[12]. These figures were calculated by taking into account the nutrients supplied by mud (mill specific), the respective grower's fertiliser usage and feedback from technical specialists. As noted in the table, all farms obtain similar savings from reduced N use. However, the farmers at sites C and D do not commonly apply fertilisers that contain large quantities of P as their soils already contain sufficient quantities. Accordingly, these farms cannot derive as much savings in fertiliser expenses as those at sites A and B.

Table 8: Fertiliser savings (kg/ha) and cost savings ($/ha).

Site	Treatment	N	P	K	S	$/ha
A	200t/ha conv.	60	45	96	24	$389
	100t/ha conv.	20	45	96	24	$333
	65t/ha banded	20	45	85	21	$313
C	200t/ha conv.	60	0	91	17	$239
	100t/ha conv.	20	0	91	17	$183
	120t/ha banded	-	-	-	-	-
	65t/ha banded	20	0	91	14	$180
	35t/ha broad.	0	0	60	8	$98

Site	N	P	K	S	$/ha
B	60	38	64	12	$307
	20	38	64	12	$251
	20	38	64	12	$251
D	60	0	0	25	$110
	20	0	0	22	$51
	20	0	0	25	$54
	-	-	-	-	-
	-	-	-	-	-

5.1.3 Comparison of mud cartage, fertiliser and cultivation expenses

Figure 1 examines the total expenditure on mud cartage, fertiliser and cultivation from when the trial started until the end of the current crop cycle (see Table 4). Cultivation has been included as it is used to incorporate mill mud in certain treatments, therefore influencing the relative cost of each treatment. The total cartage, fertiliser and cultivation expenses are shown above each column in the charts.

A comparison of the mud scenarios highlights substantial differences in costs between the trial sites. For most of the sites, cultivation expenses are higher for the conventionally applied scenarios as the mud needs to be incorporated into the soil to improve the flow of irrigation water down the furrow. The chart for Site A indicates that large savings in fertiliser costs can be obtained from applying mud, however these are outweighed by high mud cartage costs (price = $6/t) for all the mud treatments. Compared to spreading mud conventionally at 200t/ha, banding mud at 65t/ha costs around $750/ha less over the three ratoon crops.

Likewise, Site B can potentially obtain large savings in fertiliser costs. However, mud cartage costs are around half the amount for this site compared to Site A. Consequently, the overall costs for the mud treatments at this site are more comparable to the no mud treatment. For Site B, the expense to band mud is around $158/ha lower than applying mud conventionally at 200t/ha. At this site, banding mud is potentially cheaper than not applying mud at all (over the first and second ratoons) due to savings in fertiliser costs.

Mud cartage costs for sites C and D are comparatively low as they are located within five kilometres of the mill. While Site C can obtain some fertiliser cost savings in N, K and S, Site D can realise few savings as the soil already had surplus P and K.

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[12] The potential fertiliser savings are likely to vary in later crop cycles as savings are dependent on the soil nutrient balance (identified by soil testing).

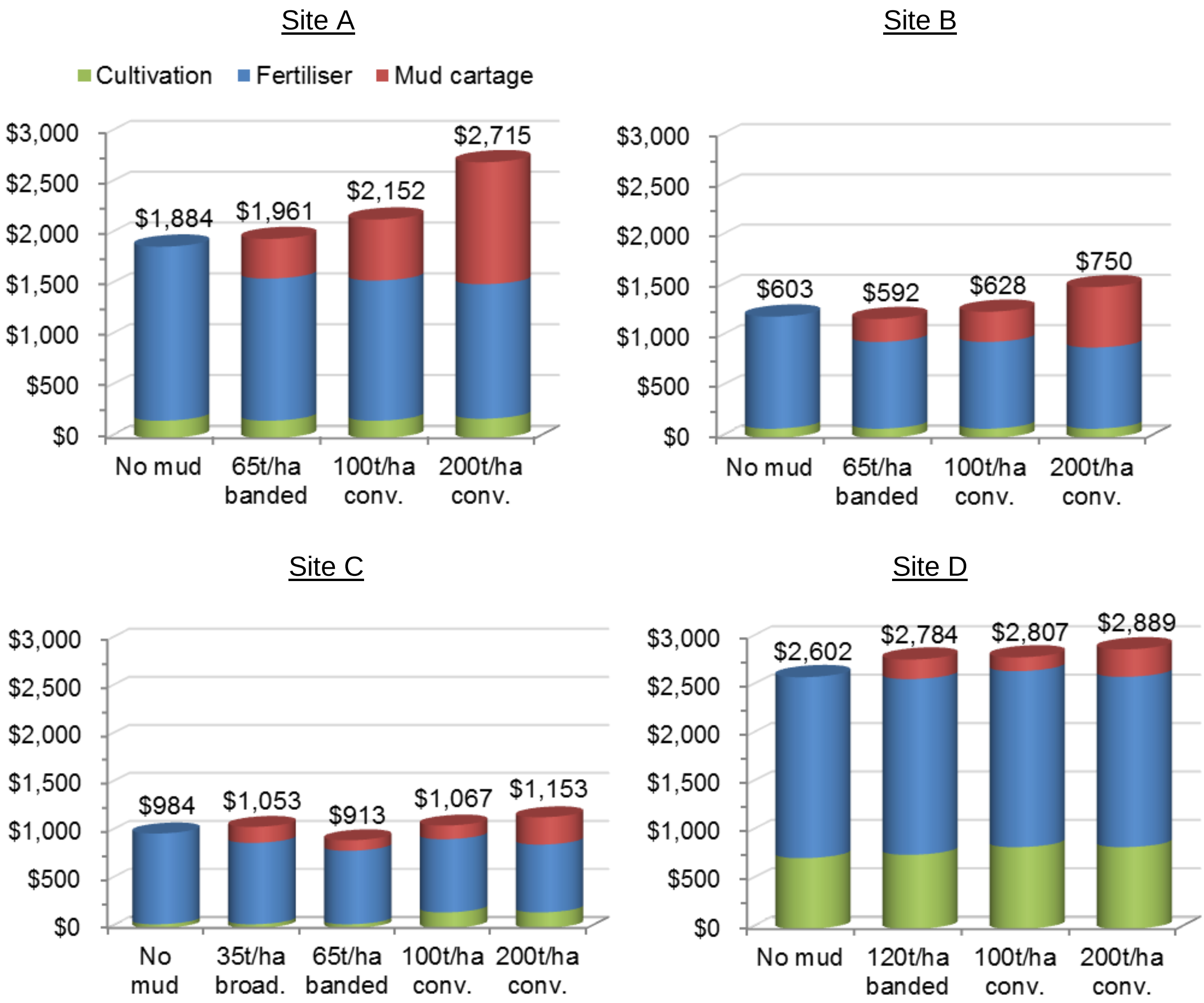

Figure 1: Mud cartage, fertiliser and cultivation expenses until last ratoon ($/ha).

5.2 Break-even yield analysis

Figure 2 compares the average gross margin over the remaining ratoons for each treatment when assuming that every treatment has the same production (respective of trial site). The variation in gross margin between each scenario is predominantly due to the differences in mud, fertiliser and cultivation expenses that were presented above. All other variable growing expenses (e.g. weed and pest control, irrigation, etc.) remained very similar between scenarios. Consequently, the graphs below show similar results to those presented above.

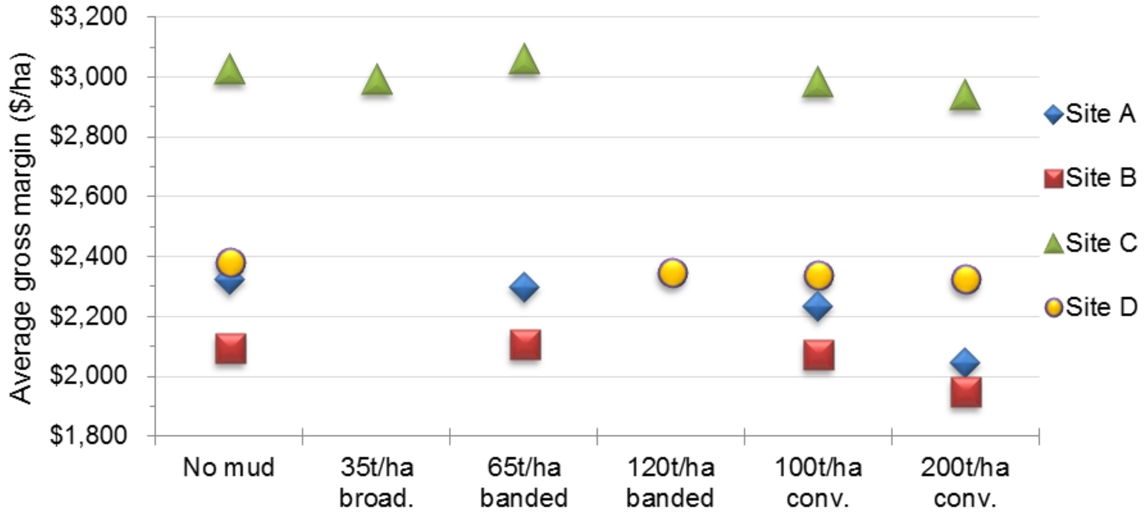

Figure 2: Average gross margin over remaining ratoons.

Figure 3 presents the annualised equivalent benefit[13] of investing in mud for each of the different treatments when assuming that production (yield and CCS) is the same for all treatments. The annualised benefit takes into account the expenditure on mud application as well as differences in growing costs (e.g. cultivation and fertilising expenses). It enables a comparison of each investment's (or treatment's) average annual return over the period that mud provides tangible benefits (i.e. life of the investment). Assuming yields are the same among treatments, nearly all of the mud treatments deliver a negative annualised benefit. Consequently, an improvement in production (yield or CCS) is necessary for the mud treatments to be profitable (except for the 65t/ha banded treatments at sites B and C).

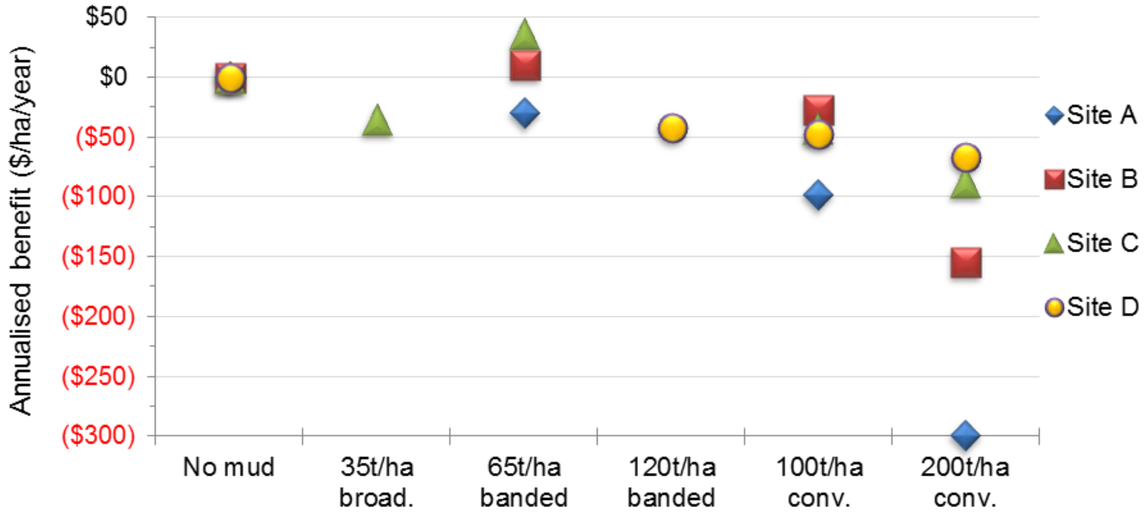

Figure 3: Annualised benefit (or cost) of each mud investment.

To put these cost differences into perspective, Figure 4 examines the total cane yield improvements that are needed by each mud treatment to obtain the same profitability as the no mud treatment[14]. Two scenarios are examined by the column charts; the shaded areas display the yield improvements needed inclusive of fertiliser cost savings, while the cross sectioned areas show the additional yield needed when fertiliser rates are not adjusted for the nutrients supplied by mud. The yield

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[13] The annualised equivalent benefit is a transformation of an investment's net present value. It is a useful measure to compare the performance of investments that produce benefits over different horizons.

[14] As there is some variation depending on what year the additional yield was realised (due to the time value of money), the average has been shown.

improvements are the totals required to break-even[15] (total = first ratoon + second ratoon + third ratoon). As noted in the charts, the adjustment of fertiliser rates can reduce the break-even yield considerably, particularly at sites that generally apply large quantities of P, K and S as fertiliser (e.g. sites A and B).

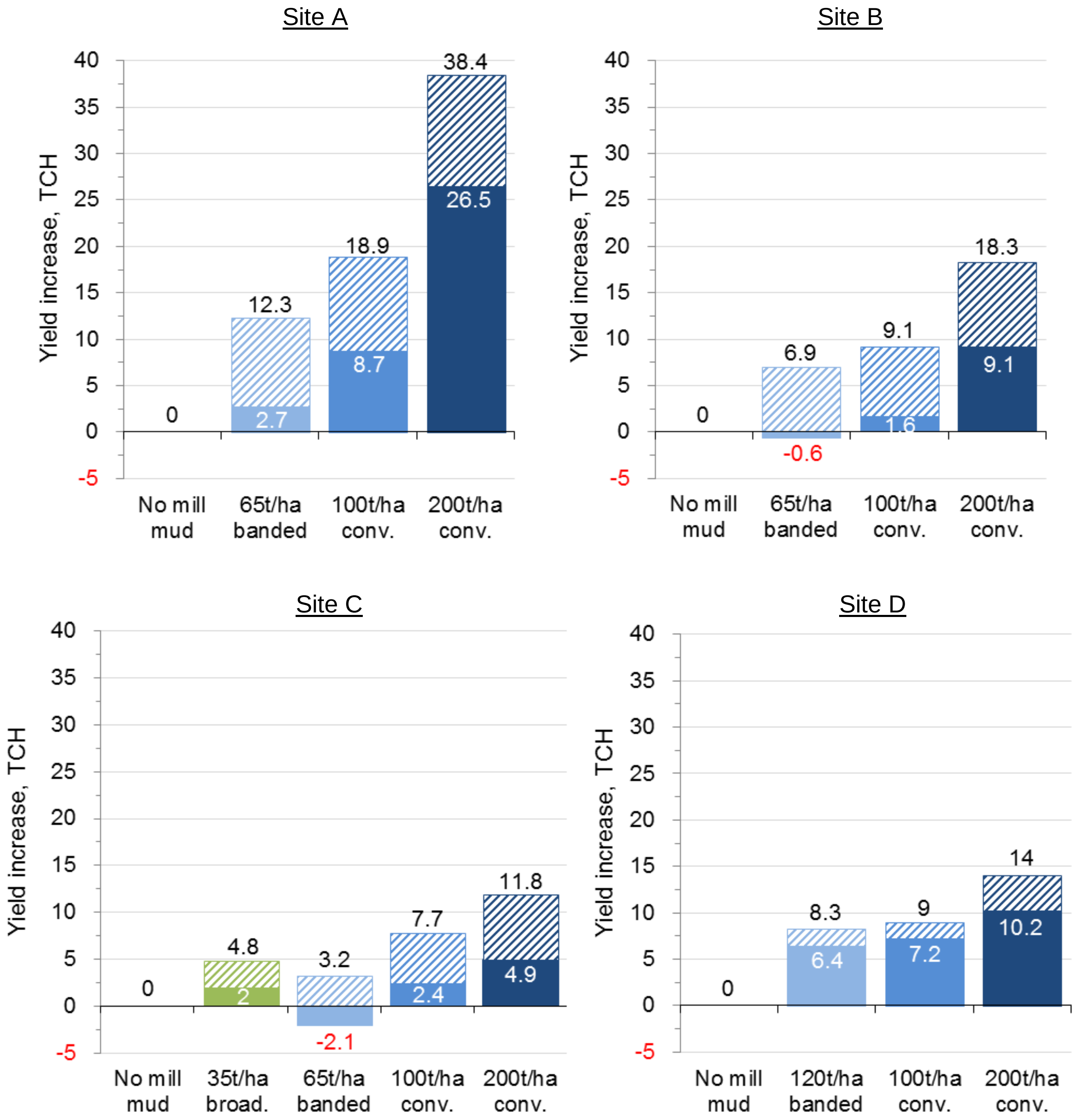


Figure 4: Total cane yield improvement needed to break-even at each site.

By examining a variety of trial sites across farms, it is possible to gain a better understanding of the variation that is likely to be experienced by farms in the broader region. Figure 5 compares the results from each site inclusive of fertiliser cost savings.

[15] The analysis assumes a constant CCS level and that all other input costs remain constant (weed control, harvesting prices, etc.).

As the 'no mud' scenario generally has the lowest costs, most other scenarios require a comparatively higher yield to afford them similar profitability. The following list identifies the yield improvement (the range from all sites) necessary for each mud treatment to break-even with the no mud scenario:

- 200t/ha conventional, 5 to 26.5 t/ha
- 100t/ha conventional, 1.6 to 8.7 t/ha
- 120t/ha banded, 6.4 t/ha
- 65t/ha banded, -2.1 to 2.7 t/ha
- 35t/ha broadcast, 2 t/ha

In the case of the 65 t/ha banded treatment, a slight reduction in yield may occur (at sites B and C) and it can still 'break-even' with the no mud scenario.

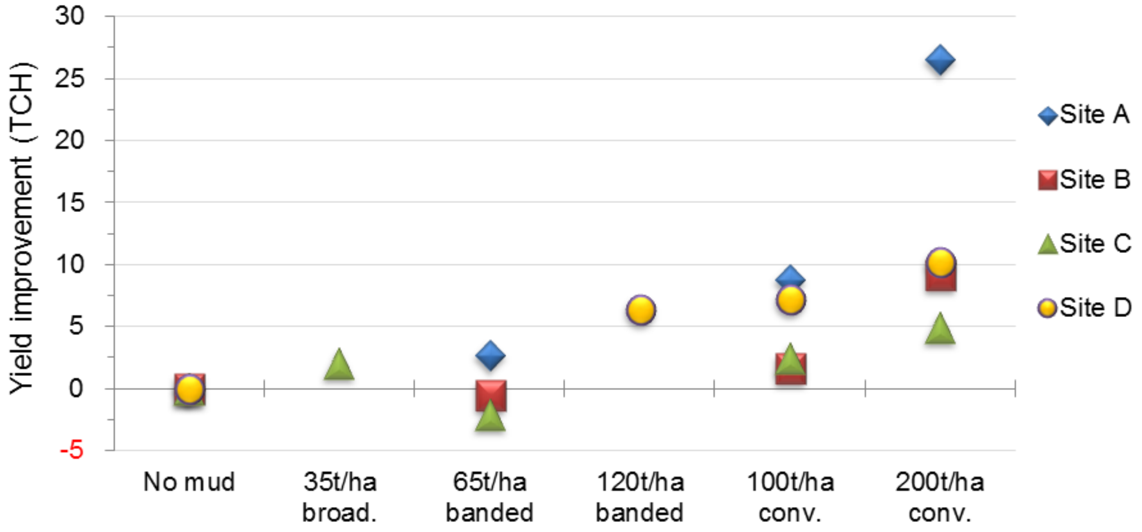


Figure 5: Cane yield improvement needed to break-even – comparison of all sites.

As banding mud is a relatively new practice in the Burdekin, the prices that have been used in this analysis could change. Such a change will likely be dependent on uptake and the impact on the operating costs and revenues of cartage operators. Figure 6 examines how the break-even yield would be influenced if the price to band mud either rose by 25 per cent, or fell by 10 per cent, at each of the sites. Comparing the sensitivity of each site identifies that the break-even yield of each site responds similarly to price changes, with the exception of Site D which is relatively more sensitive to price changes[16] (due to the higher application rate). The longer lines are a function of the price range being examined[17].

Based on the price assumptions, the break-even yield for each banded mud treatment shows some sensitivity to changes in the price to band mud. For instance, examining the range if the price to band mud at Site B fell by 10 per cent ($3.50 to $3.15/t) identifies that the 65t/ha banded treatment could sustain a relatively larger drop in yield by 0.7 TCH (from -0.6 to -1.3 TCH) to break-even. On the other hand, if the price increased by 25 per cent at Site A ($6 to $7.50/t) then the 65t/ha banded treatment would need an extra 3.1 TCH (2.6 to 5.7 TCH) to break-even.

[16] The relative sensitivity of each farm site can be compared by the slope of each line. For example, a steeper line indicates greater sensitivity to the price to band mud.
[17] This can be explained by 25 per cent of $6 (Farm A's price) being almost four times greater than 25 per cent of $1.68 (the price paid by farmers at sites C and D).

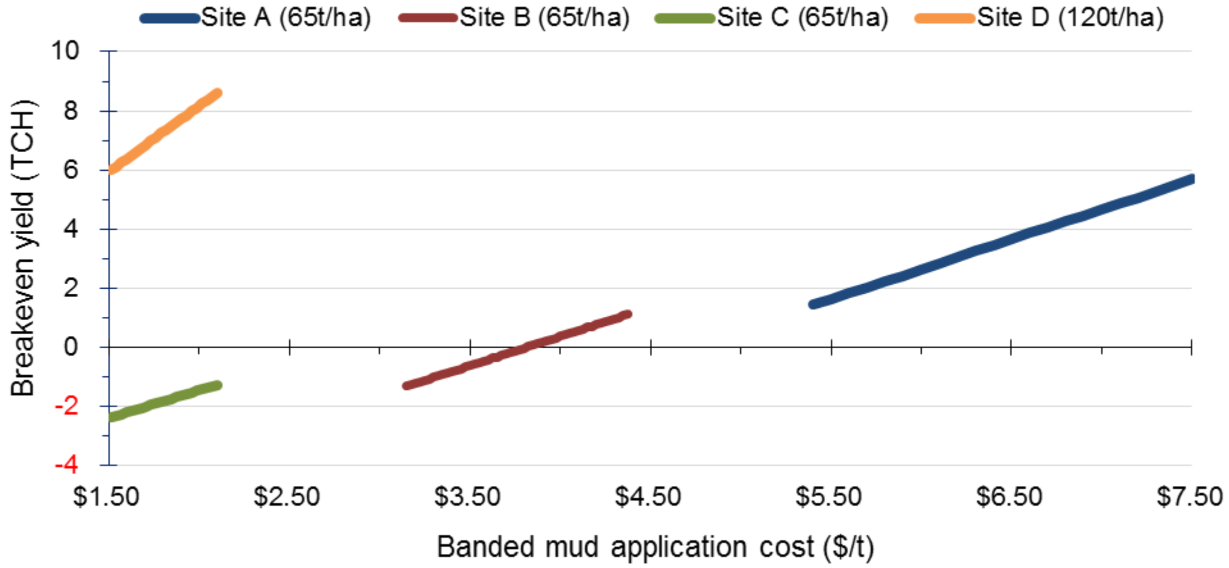


Figure 6: Sensitivity of the break-even yield to changes in the cost to band mud.

5.3 2015 production analysis

The analysis in this section utilises 2015 harvest data to examine the relative profitability of each mud treatment at each of the four trial sites after the 2014-15 season. The results from each trial site are examined individually to distinguish peculiarities between each, such as different locations (distances from mill), treatments, management practice regimes, etc.

5.3.1 Site A

Location:	Mulgrave, BHWSS		Crop stage:	2nd ratoon		Soil type:	Clay, sodic subsoils
Distance from mill:	~50km (Invicta)		Crop cycle:	4 ratoons		Fertiliser:	Granular

Table 9 compares the trial block's production results from the 2015 harvest; TCH, CCS and tonnes of sugar per hectare (TSH). An analysis of variance (ANOVA) was performed on each of the production measures, which found that the F-tests for TCH and TSH were statistically significant at the 5 per cent level, indicating significant effects of treatment. Pairwise comparisons established that the 200t/ha conventionally spread mud treatment had both significantly higher cane yield and sugar yield than all of the other treatments.

Table 9: Mean production results from 2015 harvest – Site A.

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha	*Prob. (F)*	*95% LSD*[18]
Cane yield (TCH)	118.4 b	131.7 a	124.1 b	120.1 b	*0.011*	*6.7*
CCS	15.0 a	14.7 a	14.8 a	14.8 a	*0.456*	*n/a*
Sugar yield (TSH)	17.7 b	19.3 a	18.3 b	17.7 b	*0.023*	*1.0*

Figure 7 uses the 2014-15 trial production results to calculate the mean gross margin for each treatment in the second ratoon crop (assuming that fertiliser rates are being adjusted for the nutrients supplied by the mud). The chart on the left shows the no mud treatment achieved a gross margin higher than each of the mud treatments. Importantly, these gross margin results take into account the high mud cartage costs (due to the long distance from the mill), but only incorporate the yield improvements obtained by each treatment in the first production year after mud was applied. If production improves in the following years, or fertiliser cost savings are made, then these will improve the relative economic performance of the mud treatments.

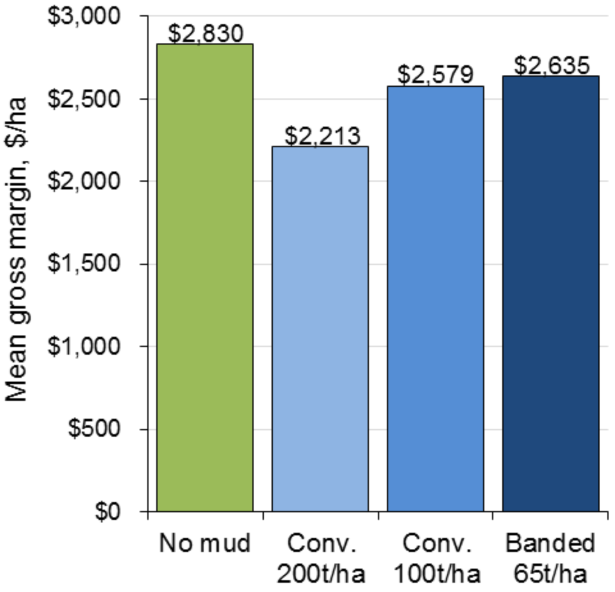
The chart on the right is similar to the other chart but separates the gross margin into two components to identify the proportion of mud cartage costs that have been recovered by increased yield and fertiliser cost savings. Together, the shaded and cross-sectioned areas represent the mean gross margin (just like in the chart on the left), while the shaded area alone represents the gross margin for the no mud treatment minus the respective mud cartage costs[19] of each treatment. This allows the cross-sectioned area to denote the amount of mud cartage costs that have so far been recovered via yield improvements and fertiliser cost savings, relative to the no mud treatment. The areas represented by the dashed lines and arrows (above the gross margins) identify the improvements still needed by each treatment to break-even with the zero mud treatment.

The chart on the right is similar to the other chart but separates the gross margin into two components to identify the proportion of mud cartage costs that have been recovered by increased yield and fertiliser cost savings. Together, the shaded and cross-sectioned areas represent the mean gross margin (just like in the chart on the left), while the cross-sectioned area alone[20] denotes the amount of

[18] 95 per cent Least Significant Difference (LSD).
[19] Just the shaded area alone represents what the gross margin would be for each treatment if it yielded exactly the same as the no mud treatment (the difference between them are the mud cartage costs only). If each of the mud treatments recovered just their mud cartage costs then they would have the same mean gross margin as the no mud treatment.
[20] Just the shaded area alone represents what the gross margin would be for each treatment if it yielded exactly the same production (TCH, CCS) as the no mud treatment (the difference between them are the mud cartage

mud cartage costs that have so far been recovered via yield improvements and fertiliser cost savings (relative to the no mud treatment). The areas represented by the dashed lines and arrows (above the gross margins) identify the improvements still needed by each treatment to break-even with the zero mud treatment.

As explained earlier, the 200t/ha treatment has much larger mud cartage costs than the rest of the mud treatments necessitating relatively larger yield improvements and/or fertiliser cost savings. So far, all of the mud treatments have recovered around half of their respective mud cartage costs after the first harvest. Consequently, all of the mud treatments need gross margin improvements during later ratoon crops to recover their whole sum and break-even.



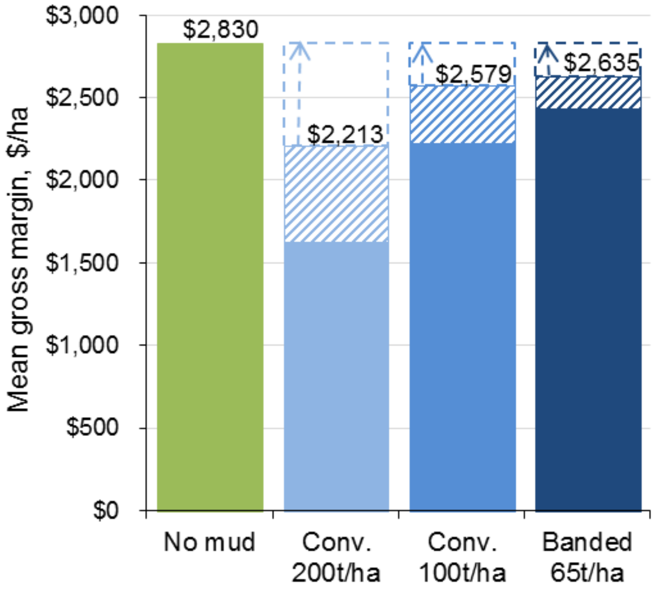


Figure 7: Gross margin analysis – Site A.

Table 10 updates the break-even analysis (for Site A) from Figure 4 with the 2015 trial results. Including fertiliser cost savings, the 200t/ha and 100t/ha conventionally spread treatments need an extra 16.8 and 5.6 TCH[21], respectively, in the following crop/s to break-even with the no mud treatment (e.g. the 200t/ha treatment needs an extra 10 TCH in the third ratoon and 6.8 TCH in the fourth ratoon to break-even with the no mud treatment). Comparatively, the 65t/ha banded mud treatment only needs 3.7 TCH more than the no mud treatment to break-even, which is 13 TCH less than the common industry practice of conventionally spreading mud at 200t/ha. For this trial site, fertiliser cost savings can greatly reduce the yield improvement needed to break-even.

Table 10: Break-even cane yield (TCH).

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha
Including fertiliser cost savings	0	16.8	5.6	3.7
Excluding fertiliser cost savings	0	29.2	16.2	13.8

costs only). If each of the mud treatments recovered just their mud cartage costs then they would have the same mean gross margin as the no mud treatment.

[21] Assuming a constant CCS.

5.3.2 Site B

Location:	Giru, BHWSS	Crop stage:	1st ratoon	Soil type:	Sandy loam
Distance from mill:	~10km (Invicta)	Crop cycle:	2 ratoons	Fertiliser:	Liquid

Table 11 compares Site B's production results from the 2015 harvest. ANOVA was performed on each of the production measures, which found that the F-tests for both cane and sugar yield were statistically significant at the 5 per cent level indicating significant effects of treatment. Pairwise comparisons established that both the 200t/ha conventionally spread mud treatment and the banded treatment had significantly higher cane yield than the no mud treatment, while all the mud treatments were found to have significantly higher sugar yield than the no mud treatment.

Table 11: Mean production results from 2015 harvest – Site B.

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha	*Prob. (F)*	*95% LSD*
Cane yield (TCH)	78.4 b	100.2 a	90.2 ab	95.8 a	*0.035*	*12.2*
CCS	14.80 a	14.75 a	14.85 a	14.90 a	*0.829*	*n/a*
Sugar yield (TSH)	11.6 b	14.8 a	13.4 a	14.3 a	*0.025*	*1.6*

Figure 8 examines the mean gross margin for each treatment at Site B in the first ratoon crop. As you can see, each of the mud treatments achieved a higher gross margin than the no mud treatment, with the 65 t/ha banded treatment achieving the highest gross margin. The chart on the right separates the gross margin into two components to identify the amount of mud cartage costs that have been recovered by increased production and fertiliser cost savings. Compared to the no mud treatment, each of the mud treatments produced more than enough extra production and fertiliser savings in the first harvest to pay back the total sum of their mud cartage costs and then some.

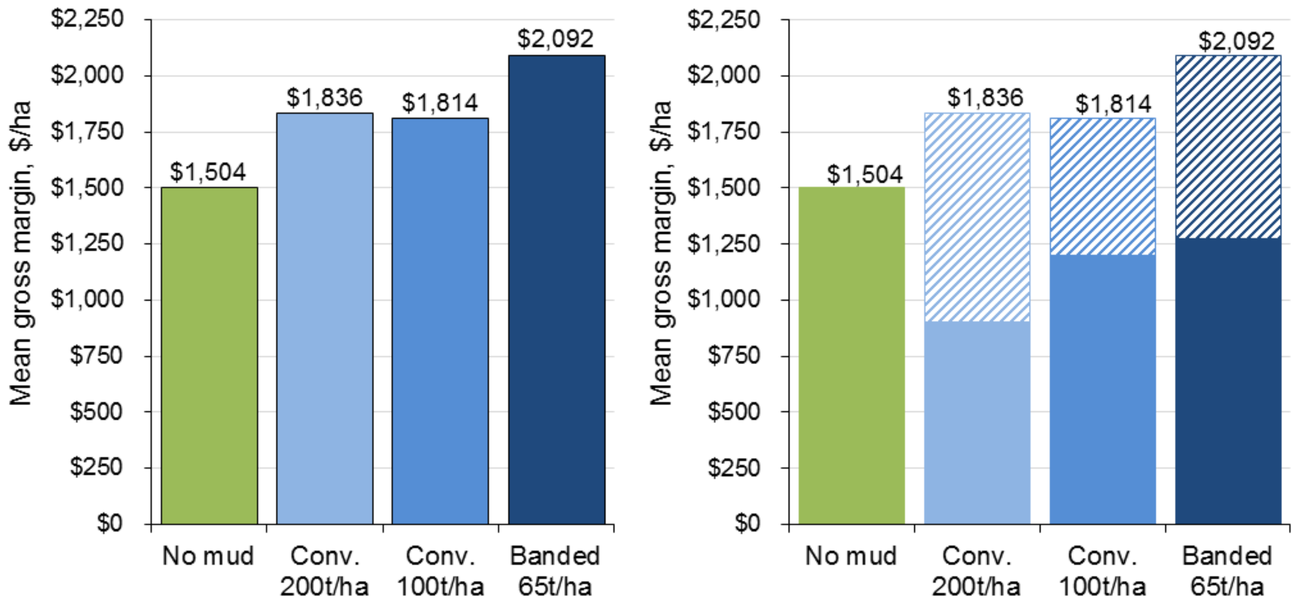


Figure 8: Gross margin analysis – Site B.

Table 12 updates the break-even analysis (from Figure 4) for Site B with the 2015 trial results. No yield improvement is needed by any of the mud treatments in later ratoon crops as they all attained higher gross margins than the zero mud treatment. While not expected to occur, each of the mud treatments could actually have a drop in production and still break-even with the control treatment. As noted by the differences in break-even yield between the with-and-without scenarios, fertiliser cost savings can improve the economic outcome at this trial site.

Table 12: Break-even cane yield (TCH).

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha
With fertiliser cost savings	0	-12.8	-11.3	-19.9
Without fertiliser cost savings	0	-3.4	-3.6	-12.2

5.3.3 Site C

Location:	Kalamia, Delta	Crop stage:	3rd ratoon	Soil type:	Loam
Distance from mill:	~2km (Kalamia)	Crop cycle:	4 ratoons	Fertiliser:	Dunder

Table 13 compares Site C's production results from the 2015 harvest. ANOVA was performed on each of the production measures. While the mean cane yields and mean sugar yields for the mud treatments were considerably higher than those produced by the no mud treatment (particularly for the 100t/ha conventionally spread mud treatment), the F-tests for all the measures were not found to be statistically significant. It is important to note here that the broadcast treatment was not included in the statistical analyses as it was not replicated. Instead, it is shown here merely to inform readers.

Table 13: Mean production results from 2015 harvest – Site C.

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha	*Prob. (F)*	*95% LSD*	Broad. 35t/ha*
Cane yield (TCH)	126.8 a	145.7 a	157.1 a	144.9 a	*0.245*	*n/a*	*151.5*
CCS	15.7 a	15.5 a	15.7 a	15.0 a	*0.161*	*n/a*	*14.9*
Sugar yield (TSH)	19.8 a	22.5 a	24.6 a	21.7 a	*0.189*	*n/a*	*22.6*

* Not included in statistical analyses

Figure 9 draws on the 2015 harvest data from the third ratoon crop to calculate the average gross margin for each treatment at Site C. The results show that all of the mud treatments achieved a higher gross margin than the no mud treatment, with the 100t/ha conventionally applied treatment achieving the highest gross margin. The chart on the right displays the gross margin separated into two components in order to isolate the amount of mud cartage costs that have been recovered by increased production and fertiliser cost savings. Compared to the no mud treatment, each of the mud treatments generated enough extra production and fertiliser cost savings in the first harvest to pay back the mud cartage costs and make additional earnings.

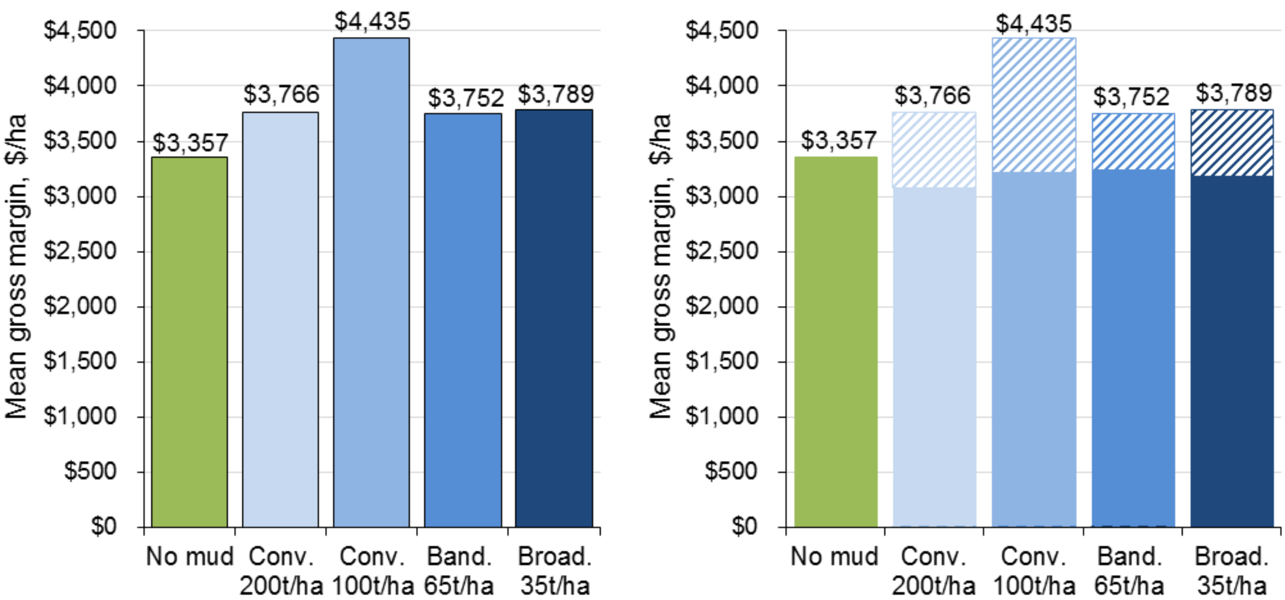


Figure 9: Gross margin analysis – Site C.

Table 14 uses the 2015 trial results to update the previous break-even analysis for Site C. As all the mud treatments attained higher gross margins than the no mud treatment, no yield improvement is needed in future crops. Instead, and while not anticipated, each of the mud treatments could potentially afford a drop in production and still break-even.

Table 14: Break-even cane yield (TCH).

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha	Broad. 35t/ha
With fertiliser cost savings	0	-12.4	-35.6	-9.7	-12.3
Without fertiliser cost savings	0	-6.3	-28.3	-6.8	-10.6

5.3.4 Site D

Location:	Ayr, Delta
Distance from mill:	~4km (Kalamia)

Crop stage:	1st ratoon
Crop cycle:	5 ratoons

Soil type:	Clay loam
Fertiliser:	Granular

Unfortunately, the banded mud treatment suffered from management issues at this trial site, which were reflected in the poor cane yields that were achieved by the 120t/ha banded mud treatment. After banding the mud at such a high rate over the stool (this was the only trial site that banded mud at 120t/ha instead of 65t/ha), the stool splitter had to apply fertiliser at an excessive depth. Unknown to the operator at the time, the wet mud clogged up the chutes and restricted the amount of fertiliser being applied.

Table 15 compares Site D's production results from the 2015 harvest. ANOVA was performed on each of the production measures with the results showing that all the treatments had significantly higher cane yield than the 120t/ha banded mud treatment. While not being significantly different, it is important to note that the 100t/ha conventionally spread treatment had much lower CCS than the other treatments. Considering the 200t/ha conventionally spread treatment attained almost the highest mean CCS, it does not seem logical that spreading mud conventionally at a lower rate would have a negative impact on yield. Consequently, this result may be due to chance (a random occurrence).

Table 15: Mean production results from 2015 harvest – Site D.

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 65t/ha	*Prob. (F)*	*95% LSD*
Cane yield (TCH)	148.0 a	149.2 a	144.6 a	128.2 b	*0.025*	*11.1*
CCS	13.0 a	13.6 a	12.2 a	13.7 a	*0.131*	*n/a*
Sugar yield (TSH)	19.3 a	20.2 a	17.7 a	17.5 a	*0.172*	*n/a*

Figure 10 examines the mean gross margin for each treatment at Site D in the first ratoon. Overall, the no mud treatment and the 200t/ha conventionally applied mud treatment achieved very similar gross margins. Regrettably, the banded treatment suffered from management issues, which contributed to poor cane yield and an obvious negative impact on the gross margin outcome. Even more conspicuous, however, is the poor economic performance of the 100t/ha conventionally spread mud treatment. As mentioned previously, this treatment had relatively low CCS compared to the other treatments but is unexplainable given the 200t/ha treatment had double the quantity of mud placed in the same location but suffered no adverse effect on CCS. These results demonstrate the value of CCS and the dramatic impact that losses or gains in CCS can have on economic outcomes.

The chart on the right separates the gross margin to identify the proportion of mud cartage costs that have been recovered (or lost) by increased (or decreased) production and fertiliser cost savings. For the 100t/ha conventionally applied treatment and the 120t/ha banded treatment, the red cross-sectioned areas represent the relatively lower production (and resulting impacts on gross margin) from these treatments compared to the no mud treatment. While keeping the management issues and unexplained CCS occurrences in mind, the results show that the 100t/ha treatment and the 120t/ha banded treatment will need to produce extra tonnes in the following ratoon crops to make up for the lost tonnes from this crop in order to generate enough revenue to break-even. In contrast, the 200t/ha conventionally spread mud treatment produced just enough extra production and fertiliser savings to pay back the total mud cartage costs in the first harvest.

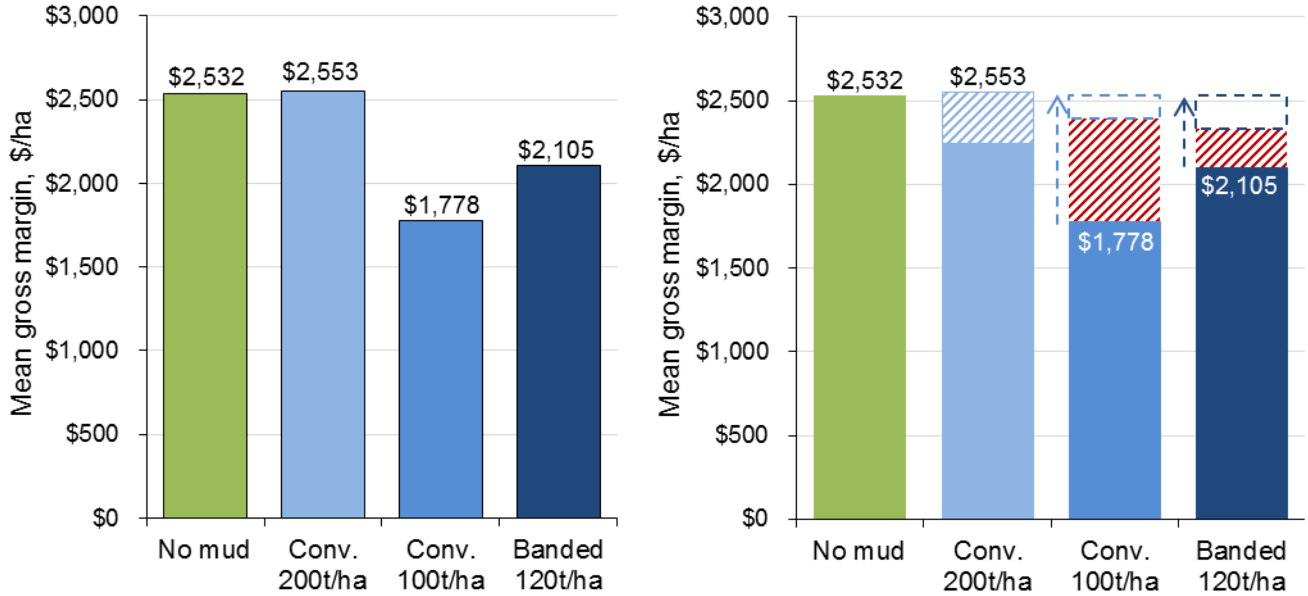


Figure 10: Gross margin analysis – Site D.

Table 16 updates the break-even yield analysis for Site D using the 2015 trial results. The results show that the 200t/ha treatment does not need a yield improvement to break-even. Due to the poor CCS performance of the 100t/ha conventionally applied treatment in 2014-15, it will need an extra 26 TCH in the following crops to break-even with the no mud treatment (inclusive of fertiliser cost savings). Similarly, the banded treatment will need around 15 TCH extra in total. Nevertheless, it is vital to keep the limitations from this trial (e.g. management issues and unexplainable CCS disparities) in mind when interpreting these results.

Table 16: Break-even cane yield (TCH).

	No mud (control)	Conv. 200t/ha	Conv. 100t/ha	Banded 120t/ha
With fertiliser cost savings	0	-1.7	26.2	14.8
Without fertiliser cost savings	0	2.2	29.4	17.5

6 Conclusion

While the application of mud can provide soil health benefits, banding mud directly on the cane row helps to reduce application costs and may decrease the risk of nutrient run-off. A fundamental question underlying the trial is whether banding mud, broadcasting mud or conventionally spreading mud, at lower application rates, can maintain or improve grower profitability relative to the common industry practice of conventionally spreading mud at 200t/ha.

Four commercial farms are analysed in detail to establish a range that might be indicative of the economic implications for similar farms in the broader Lower Burdekin region. Each of the farms are located a variety of distances from local mills and have different soils and nutrient requirements, which enables an analysis of the profitability of the mud treatments at a range of mud cartage prices and fertiliser cost savings. In particular, the report evaluates the main cost drivers and cost savings associated with applying mud and investigates the yield improvements needed by each mud treatment to break-even economically with the no mud treatment. It also uses 2015 harvest results from the trial sites to compare the gross margin for each treatment and the improvements still needed in future crops.

Distance of the farm from the mill was found to be a key cost driver. For example, the mud cartage costs to conventionally spread mud at 200t/ha at Site A, which is located around 50 kilometres from the local mill, was found to cost around $1,200/ha compared to $390/ha to band mud at 65t/ha. On the other hand, trial sites located close to the mill (sites C and D) had cartage costs of less than $300/ha when spreading 200t/ha, compared to just over $100/ha to band mud at 65t/ha.

For the trial sites with soils that require the addition of P, K and S (sites A and B), relatively larger fertiliser cost savings can be made. Using a conservative method to calculate fertiliser savings, cost savings of between $250 and $390 could be made at sites A and B (depending on the mud application rate and nutrient requirements). When comparing all the cost differences at Site A (mud cartage, fertiliser and cultivation expenses), banding mud at 65t/ha costs around $750/ha less than spreading mud conventionally at 200t/ha. However, this difference was much less at the sites closer to the mill, where cost savings ranged between $105 and $240/ha. Interestingly, the banded mud treatment at sites B and C can have lower overall costs than the no mud treatment; due to relatively low mud cartage costs compared to the potential savings in fertiliser costs.

At Site A, which is located a long distance from the mill, conventionally spreading mud at 200t/ha was found to require a total cane yield improvement of just over 25 TCH to break-even with the no mud treatment, compared to just 2.7 TCH for the 65t/ha banded treatment (inclusive of fertiliser cost savings). In contrast, the break-even cane yield for the 200t/ha conventionally spread treatment at those sites located closer to the mill were much lower; ranging between 5 and 10 TCH. Nevertheless, the 65t/ha banded mud treatments at these sites require no yield improvement.

Results from the analysis using 2015 harvest data highlight the potential for farms located far from the mill to band mud at a lower rate onto the hill as a potentially feasible alternative to conventional applications of mud at 200t/ha. Because of the high mud cartage costs at Site A, the banded treatment at 65t/ha was more cost effective than the 200t/ha treatment and requires around 14 TCH less from subsequent crops to break-even. Based on the inclusion of production benefits from only the first harvest after mud application, the mud treatments with the highest gross margin at each of the four trial sites were:

- Site A – the 65t/ha banded treatment
- Site B – the 65t/ha banded treatment
- Site C – the 100t/ha conventionally spread treatment
- Site D – the 200t/ha conventionally spread treatment, however, the banded mud treatment suffered from known management issues

Of the three sites within close proximity of the mill, two recovered the mud cartage costs from all mud treatments in the very first year after mud application (sites B and C), while Site D was the only one not to recover these costs. But again, Site D suffered from management issues. Based on the economic results from the four sites so far, there is little evidence to suggest that the 200t/ha conventionally spread treatment is more profitable than the 65t/ha banded mud treatment.

Moving forward, the inclusion of additional trial data from subsequent crops will determine the net profitability of each mud treatment and, in the case of Site A, if the obtained yield improvements are enough for each treatment to break-even with the no mud treatment. In order to statistically analyse the economic results, the full production benefits need to be understood. While the full costs of each mud treatment are known, the full benefits are not. In order to capture the total revenue benefits provided by each mud treatment, the collection of trial production data are needed over the entire time period that the mud provides yield improvements. However, this period is likely to extend past the current trial period.

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