BUREAU OF SUGAR EXPERIMENT STATIONS

QUEENSLAND, AUSTRALIA

Final Report

SRDC Project BS149S

A Reactive Extension and Monitoring Program to Reduce Dirt Levels in the Cane Supply

by

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SD97015

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BSES Publication
SRDC Final Report SD97015

November 1997

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1.0 SUMMARY

The two year project targeting soil in cane levels in different mill areas was completed in June 1997.

The project followed up research findings in BS26S on causes of high soil levels and the industry-wide extension campaign conducted in BS82S on cane loss and soil in cane levels.

Following the research findings a number of harvester factors were targeted in this project as having potential for reducing soil levels. These included: basecutter angle setting, basecutter disc type, basecutter height setting, degree of basecutter blade wear, buttlifter rotational speed, harvester forward speed and extractor speed. Demonstration trials were conducted on all these factors using either the dirt monitor at Tully Mill or, in other mill areas, ashing of prepared cane samples to assess soil levels with different harvester settings. These trials were replicated to allow statistical analysis of results. The complete trial program included measurements in the Mulgrave, Babinda, Mourilyan, South Johnstone, Tully, Pioneer, Inkerman, Millaquin and Harwood Mill areas.

A program to assess field cultural practices affecting soil in cane levels was also conducted to follow up previous survey results on row spacing and row profiles. Surveys were carried out in each region to determine both the typical range in average row spacings in a district and the variation in row spacings within individual fields. Demonstrations of prototype hiller boards developed to give a single pass operation for forming row profiles for harvesting were carried out. These boards were also used for trials on earlier hilling-up of plant cane.

Data was also collected on harvester maintenance costs attributable to soil, the effect of increased soil levels on grower ccs, and effects of soil on mill maintenance and operational costs.

The targeted monitoring and trial program throughout the state identified several potential avenues for reducing levels of soil in cane, and gave preliminary data on costs of soil in cane to the industry.

The main conclusions were:

- Soil in cane levels can be reduced significantly by adjusting the basecutter angle to match the row profile;
- Harvester forward speed and basecutter height setting have a significant effect on soil in cane levels; together with basecutter angle adjustment, correction of these factors appears to offer the best potential for reduction of soil levels;
- Use of dished basecutter discs reduced soil levels significantly in some conditions;
- Average row spacing in each district was satisfactory for current harvester wheeltracks but some narrow spacings still exist;
- Row-to-row variability in row spacings is of concern in all districts and deserves immediate attention;

- Preliminary estimates were made of costs of soil in cane to growing, harvesting and milling sectors of the industry. These showed an adverse effect on returns for all sectors from high soil levels and, in particular, for the milling sector.

Project findings together with strategies for minimising effects of wet weather on soil in cane levels provide a sound basis for future extension work to reduce soil in cane levels.

2.0 BACKGROUND

High dirt levels in the cane supply are a particular problem in north Queensland, the Burdekin area and in individual mill areas on a seasonal basis. Industry-wide it has been estimated that dirt costs in excess of $30m annually to the milling sector made up of additional maintenance and higher operational costs such as supplementary fuel for boilers. In addition, dirt intake contributes significantly to maintenance costs for harvesters and to reduced sugar quality, and lower ccs levels are conservatively estimated to cost growers $8m per annum. Historically, dirt levels increased with the adoption of mechanical harvesting and there is no evidence of a fall in dirt levels in recent years. On the contrary, surges in dirt levels in some areas are of continuing concern.

Recent research has shown that a number of factors contribute to high dirt levels including wet harvest conditions, lodged crops, varietal characteristics, cultivation practices, harvester design and harvester operating parameters such as basecutter height setting and forward speed. This research has also indicated potential avenues for reducing dirt levels.

A 30% reduction in dirt levels, estimated to be worth $11m annually to the industry, and an effective program targeted to achieve this would bring important benefits to the industry. Few programs existed outside the SRDC project BS82S to counteract unacceptable dirt levels and this project was limited by the difficulty in measuring dirt levels accurately and demonstrating benefits from programs to reduce dirt levels.

The current project was aimed at providing preventative and reactive working methods to achieve improved control of dirt levels industry-wide by utilising facilities at selected mills to demonstrate the benefits of these methods.

3.0 OBJECTIVES

- Relate operating conditions of harvesting groups with monitored, above and below average dirt levels in selected mill areas.
- Target the causes of high dirt levels using previous research and extension findings.
- Develop and demonstrate methods for reduction of dirt levels in the cane supply using a reactive and targeted extension approach.

4.0 METHODOLOGY

4.1 Harvester factors

Following earlier research findings, several harvester factors were targeted as having potential for reducing soil in cane levels:

- basecutter angle setting
- basecutter disc type
- basecutter height setting
- degree of basecutter wear
- buttlifter rotational speed
- harvester forward speed
- extractor speed

The trial program evaluating these factors included measurements in the Mulgrave, Babinda, Mourilyan, South Johnstone, Tully, Pioneer, Inkerman, Millaquin and Harwood mill areas.

4.1.1 Basecutter angle trials

The basecutter angle trials were conducted with harvesters fitted with hydraulic adjustment of the basecutter angle. A total of five trials reflecting a range of local environments were carried out at Harwood, Bundaberg, Home Hill (two) and Babinda. These included two plant cane trials with relatively flat drills and three ratoon trials with high hills. In each case, two settings of basecutter angle were used - a relatively flat angle and a steep angle. For harvesters with leg basecutters, settings corresponded to approximately 11° and 18° respectively. In the Babinda trial with a prototype underslung basecutter drive, the angles were 15° and 30°, respectively. The basecutter height for each angle was set by the operator to give effective cutting and gathering of cane. The effect of basecutter angle on soil in cane levels was assessed by cutting three rakes of cane with each setting and sampling each rake at the mill for determination of ash % prepared cane. Previous research has shown that ash % cane can be equated to soil in cane (Muller *et al.*, 1982).

Measurements of soil profiles cut with different setting angles were also carried out.

4.1.2 Basecutter disc type

Five trials were carried out with different types of basecutter discs including standard, 5° dished and scalloped discs. Three of these trials were in the Tully Mill area where soil % cane (or ash % cane) measurements were available from the online soil monitor at the mill, and two in the Pioneer Mill area in the Burdekin. Soil in cane was estimated at Pioneer by ash determinations on prepared cane samples. Separate rakes of cane were cut with each disc type with two to three replicates per type.

4.1.3 Harvester forward speed

Three replicated trials were conducted comparing fast and slow harvester ground speeds, two at Tully and one at Bundaberg. Ash values were determined using the Tully soil monitor and by ashing of prepared cane at Bundaberg.

4.1.4 Other harvester factors

Trials were conducted on a more limited scale in several mill areas to evaluate the influence of other factors such as basecutter height setting, degree of basecutter wear, buttlifter rotational speed, harvester extractor speed and soil moisture levels on soil in the cane supply.

4.2 Field factors

The field program was designed to supplement previous survey results on row spacing and row profiles (Linedale and Ridge, 1996) and to demonstrate techniques for improving row profiles. Surveys were carried out in each region to determine both the typical range in average row spacings in a district and the variation in row spacings within individual fields.

Preliminary demonstrations were carried out with prototype hiller boards developed to give a single pass operation for forming row profiles for harvesting. Early hilling-up trials were also established in plant cane to demonstrate that cane rows could be filled in earlier and more effectively than in the commonly accepted practice, without loss of yield.

4.3 Economic factors

Data were collected during harvester trials to demonstrate the impact of soil in cane on ccs levels and grower returns. Preliminary data were also collected on maintenance costs for harvester groups, attributable to soil in the cane supply. Literature on the effect of soil in cane on milling costs was also reviewed.

5.0 RESULTS AND DISCUSSION

5.1 Harvester factors

5.1.1 Basecutter angle

The results of the five trials comparing the effect of shallow and steep basecutter angles on soil % cane levels are summarised in Table 1. These indicate a significant reduction in soil levels in flat row profiles with a flat basecutter angle setting compared to a steeper angle. Conversely, in hilled row profiles, ash levels were higher with a flat angle compared to the steeper angle.

This suggests that ash (or soil) levels can be reduced significantly by setting the basecutter to the appropriate angle for particular row profiles. In flat row profiles the basecutter geometry indicates that if cane is cut effectively at ground level, a steep basecutter angle will cause the basecutter to dig in on either side of the row. In hilled row profiles harvested with a flat basecutter angle, it is necessary to cut deeper in order to gather cane growing from the side of the hill. The outcome of both these practices where the basecutter angle is set inappropriately is a substantial increase in soil intake by the harvester.

TABLE 1
Effect of basecutter angle on soil in cane levels

Angle	**Soil % cane**	
	flat culture*	**high hills****
Flat	1.46	2.39
Steep	2.10	1.52
lsd 5%	0.59	0.59

* mean of two trials
** mean of three trials

Typical cutting patterns with different basecutter angle settings for flat culture and high hills are given in Figures 1 and 2. These correspond to the soil levels in the cane supply with deeper cutting (flat profile, steep basecutter or high hills, flat basecutter) causing more soil to be taken in by the harvester.

5.1.2 Basecutter disc type

The results of two of the five trials comparing different types of basecutter discs are given in Table 2. These show a significant reduction in soil levels with 5° dished basecutter discs compared to standard basecutter discs. In these trials the basecutter angle was set at 15-16° and rows were slightly hilled up. The remaining three trials were inconclusive with no significant difference in soil levels between different disc types.

The trials have not given a clear guide to conditions where dished basecutters may be effective in reducing soil levels or to the mechanism involved. A possible contributing factor is that the blade tips are cutting below the basecutter disc and this may reduce soil flowing over the discs.

In the course of these trials it was noted that larger than standard basecutter discs fitted to leg basecutters appeared to give less stubble damage than the smaller standard discs. However, this observation was not quantified.

TABLE 2
Effect of basecutter disc type on soil in cane levels

Disc type	Soil % cane*
Standard	1.32
5° dish	1.17
lsd 5%	0.12

* Mean of two trials

5.1.3 Harvester forward speed

Results of trials conducted in four districts confirmed previous findings that increased ground speed also increases soil in cane levels in most situations (Table 3). This factor is probably more significant now than previously, due to the increased power of current commercial harvesters and the presence of more late model harvesters in the industry. Current model harvesters have significantly more power at the basecutters.

TABLE 3
Effect of harvester forward speed on soil in cane levels

Speed setting	% soil in cane			
	Tully*	South Johnstone	Babinda	Bundaberg
Fast	3.1	2.62	1.42	1.26
Slow	2.6	2.56	1.46	1.14

* Mean of five trials

5.1.4 Cutting depth

Inappropriate cutting depth resulted in a sharp increase in soil levels (Table 4) in all trials. This is a similar result to that obtained by Henkel *et al.* (1979). Benefits can be obtained by setting the basecutter angle to match drill shape and size but the correct height setting is essential for reducing soil levels. The negative effects from cutting too deep will be accentuated by excessive harvester forward speed.

TABLE 4
Effect of basecutter height setting on soil in cane levels

Basecutter setting	% soil in cane			
	Tully		South Johnstone	Bundaberg
	trial 1	trial 2		
Low	9.0	5.3	4.85	2.66

High	2.3	2.8	2.80	1.88

5.1.5 Other harvester factors

Other harvester factors tested, such as degree of basecutter wear, buttlifter rotational speed and extractor speed, were considered to offer less scope for reducing soil levels.

Basecutter wear trials gave increased soil levels as blade wear increased in some cases but no effect on soil levels in other trials. It was concluded that some operators may cut deeper as blades wear in order to minimise the amount of ragged cut stubble, but this was not a general practice. Nevertheless blade maintenance is important for minimising stubble and cane damage during harvesting. Trial results are summarised in Table 5.

TABLE 5
Effect of basecutter wear on soil in cane levels

Location	% soil	
	sharp blades	blunt blades
Tully	0.8	1.2
Mulgrave		
trial 1	1.46	1.83
trial 2	0.60	0.63

Slowing the buttlifter roller reduced soil levels by a small but non-significant amount. It was concluded that only minor improvements could be made by reducing buttlifter speed further from the relatively slow speeds used on current harvesters. Results of a trial conducted at Tully are given in Table 6.

TABLE 6
Effect of buttlifter speed on soil in cane levels

Buttlifter speed	% soil
Slow	2.1
Fast	2.5

Trials at both Tully and Mulgrave Mills showed that soil levels could be decreased by increasing primary extractor speed, but this was at the expense of increased cane losses through the extractor. Typical trial results for soil levels only are given in Table 7. This effect was clearly demonstrated by Linedale and Ridge (1996). Adjustment of extractor speeds to achieve the optimum balance between cane loss and extraneous matter levels is therefore considered the most appropriate practice.

TABLE 7
Effect of extractor speed adjustments on soil in cane levels and cane loss

Location	Extractor speed rpm	Soil % cane	Cane loss t/ha
Tully A	1200	3.8	n.a.
	1400	3.0	n.a.
Tully B	1200	3.2	n.a.
	1400	3.0	n.a.
Mulgrave	1250	0.99	8.9
	1050	2.04	3.4
	800	2.14	1.3

Trials comparing wet conditions and a time sequence as the soil dried out at Tully and Harwood clearly demonstrated that significant reductions in soil levels could be achieved by delaying start-up after wet weather. This confirms earlier results of Henkel *et al.* (1979) and Ridge and Dick (1992) comparing wet and dry cutting conditions. Typical drying out trends are illustrated in Table 8. The impact of drying out varies with soil type and field conditions.

TABLE 8
Effect of delayed harvest after wet weather on soil in cane levels

Delay (days)	Ash % cane	
	Tully*	Harwood**
0	1.4	4.75
1	0.8	3.49
2		3.30

* red clay loam
** clay soil

5.2 Field factors

5.2.1 Row spacing

Results of row spacing surveys which encompassed most districts are summarised in Table 5, and indicate that there is a range of average row spacings in each district. However, overall district averages are 1.5 m or more, suggesting that row spacings are becoming more compatible with the wheel spacing of current harvesting equipment. Farms with spacings less than 1.5 m will create problems in harvesting due to wheel traffic being too close to adjacent rows. This causes breakage of stalks prior to harvesting, and in wet conditions distortion of the row profile. Both factors cause higher soil levels due to the need to cut deeper to gather all the cane. Previously, this was documented by Ridge and Dick (1992) in studies of paired high and low soil farms at Tully where narrow rows were associated with high soil levels.

Within block variation in row spacings is also indicated in Table 9 and the high variability in some blocks is a serious cause for concern. Figure 3 shows typical patterns of row spacings for relatively uniform and highly variable blocks. The distribution of variability in spacing between successive rows for the Mackay and Isis surveys is shown in Figure 4. This indicates that, while a majority of adjacent rows have relatively uniform spacings, there is a significant proportion with large variations from interspace to interspace. Variable row spacings will cause similar problems with wheel traffic close to rows to those noted with narrow row spacings. In addition, cultivation with multi-row equipment will create a range in row profile shapes and sizes. This is likely to accentuate soil in cane problems caused by poor basecutter height settings. More care in marking out blocks for planting and in the planting operation itself should help overcome this problem.

TABLE 9
Average district row spacings, variability within districts and variability within blocks

District	Mean row spacing (mm)	District range (m)	Within block row spacing variation		
			max-min range (m)	St. dev. range	number of blocks
Cairns	1.53	1.47-1.57	0.10-0.25	0.04-0.09	12
Babinda	1.53	1.51-1.57	0.10-0.25	0.04-0.09	12
Innisfail	1.54	1.49-1.74	0.13-0.42	0.04-0.12	19
Tully	1.55	1.49-1.63	0.20-0.80	0.05-0.19	10
Ingham	1.51	1.40-1.62	n.a.	n.a.	32
Burdekin					
Plant	1.55	1.48-1.59	0.05-0.60	0.02-0.18	18
Ratoon	1.54	1.50-1.58	0.09-0.30	0.03-0.14	23
Mackay	1.52	1.45-1.63	0.07-0.33	0.02-0.11	19
Bundaberg					
Bingera	1.52	1.47-1.54	0.07-0.68	0.02-0.20	20
Fairymead	1.48	1.40-1.56	0.14-0.49	0.04-0.10	19
Millaquin	1.50	1.46-1.60	0.07-0.39	0.03-0.09	16
Childers	1.55	1.49-1.65	0.15-0.30	0.05-0.08	20
Nambour	1.50	1.36-1.57	0.24-0.55	0.05-0.12	8
Condong	1.51	1.42-1.63	0.07-0.29	0.03-0.09	32
Harwood	1.48	1.35-1.58	0.10-0.78	n.a.	10

5.2.2 Hilling up

Prototype hilling-up boards have been tested in several districts to develop a single pass method of forming suitable profiles for harvesting (Figure 5). The boards are adjustable for different row spacings and have a cutout shape of the desired row profile on the underside of the trailing edge of each board. Adjustable wheels give good control of depth of cut by the boards. Cultivation of the interspace may be necessary prior to using the boards in some blocks in order to provide sufficient loose soil for the filling-in operation.

Demonstration trials with early filling-in of plant cane were established to encourage filling-in before there is sufficient bulk of cane in the row to prevent even flow of soil into the drill. Observations in these trials indicate no adverse effect from early filling-in and this agrees with historical research at Bundaberg.

5.3 Economic factors

5.3.1 Grower effect

Data collected from basecutter angle and basecutter disc type trials in the Burdekin show a reduction in ccs of approximately 0.18 units per 1% increase in soil levels. This represents a significant loss to growers that outweighs the gain from additional weight of cane recorded at the mill due to the soil content. Table 10 shows one example of the effect of soil on grower income.

TABLE 10
Effect on growers return of a 1% increase in soil in the cane supply

Loss/or gain in income*	
Loss due to lower ccs	$57.00
Gain due to additional weights	$32.00
Nett loss to grower	**$25.00**

* for 100 tonne of cane, price of sugar $350/tonne, 0.18 units ccs loss per % soil

Additionally, stool damage associated with harvesting or cultural practices which contribute to high soil levels may result in significant yield loss in subsequent crops. Running on the row, for example, has resulted in crop cycle losses as high as 16% in some varieties (Braunack, pers. comm.). Similarly, stubble damage caused by cutting with blunt basecutter blades at excessive harvester forward speeds may also impact on yields of subsequent ratoons.

5.3.2 Harvester effect

Limited data on harvester maintenance costs attributable to soil in cane were obtained from two large groups (>100 000 tonnes) cutting on contrasting soil types at Bundaberg. On a non-abrasive red volcanic soil type abrasion related maintenance was approximately 44 per tonne of cane; in contrast, on highly abrasive fine sandy soil, the figure was 16.74 per tonne. Details of these costs are given in Table 11. Obviously soil related maintenance costs will vary considerably with operating conditions, but the higher figure represents a significant proportion of total maintenance costs of 754 to 924 per tonne reported by McWhinney *et al.* (1988).

TABLE 11
Harvester wear costs for different soil conditions in >100 000 tonne group

Harvester component	Wear related maintenance ($/tonne)	
	low wear situation*	high wear situation**
Basecutter and chopper blades	3 285	8 451
Basecutter discs	-	3 020
Wear rings extractors	231	702
Hard facing	100	n.a.
Extractor blades	400	1 604
Elevator chains		4 272
Elevator floors		1 600
Total	**4 016**	**19 649**

* red volcanic clay soil
** fine sandy loam soil

Soil in cane contributes to the overall tonnage in a contract and it is important that the negative effect of increased wear is realised.

5.3.3 Miller effect

Wear problems in mills due to soil in cane are well documented with maintenance costs in the range $0.60-$1.00 per tonne of cane being quoted. In addition soil affects extraction efficiency and can result in increased fuel costs due to its effect on the calorific value and firing quality of bagasse. It can also impact on season length due to the additional weight of material and reduced clean cane crushing rates caused by higher 'fibre' throughput. These costs can be only approximately estimated but conservatively they are a minimum of $1 per tonne taking into account the increased share of sugar monies at lower ccs.

5.4 Extension program

An integral part of the project was extension of findings on strategies for reducing soil in cane on a regional basis. This included meetings at Tully, throughout the southern region as part of BSES information meetings and on a local basis at Nambour and Rocky Point, and information meetings in northern New South Wales. The dirt in cane programme was also highlighted at field days on all BSES experiment stations and roving field days in other centres. Demonstrations on hilling-up were also carried out at Tully and in Bundaberg.

In the Tully area and in northern New South Wales, row profile templates were developed and used widely for demonstrating ideal row profiles for harvesting with minimum intake of soil.
The findings on harvester factors and field conditions for minimising soil in cane, together with strategies for reducing the impact of wet weather form the basis for a potential

ongoing extension program to reduce soil in cane levels. It is felt that better 'management' of wet weather harvesting such as starting first on low risk soil types (eg sands); avoiding high risk field conditions (eg grub damaged blocks, lodged and stool tipped cane, blocks with poor row profiles); in addition to starting later after wet weather can make a significant contribution to lower soil levels.

6.0 DIFFICULTIES ENCOUNTERED DURING THE PROJECT

The main difficulty encountered during the project was the lack of a simple method of measuring soil in cane levels in most mill areas. For trial purposes soil in cane was estimated by ashing samples of prepared cane taken at the mill. This gave a good estimate of the impact of specific treatments on soil in cane levels, but it was not possible to obtain a general estimate of the impact of factors such as poor field conditions on soil in cane levels in most mill areas. The lack of a method of identifying high soil levels, and targeting the causes was a serious drawback to the project. Similarly there is no simple method of providing feedback to growers/contractors as an incentive to better performance or a disincentive to poor performance.

It was therefore necessary to identify and target techniques for reducing soil levels and promote these in a general way rather than targeting particular cases.

7.0 RECOMMENDATIONS FOR FURTHER RESEARCH

The project highlighted two major contributing factors to high soil in cane levels:

- harvester operating parameters and adjustments/modifications
- field conditions

On the harvester side - there are several major contributing factors to high soil in cane levels that warrant further research:

- inadequate basecutter height control - more research on automatic basecutter height control is warranted.
- a better system of gathering of cane would reduce the need for deeper cutting to gather all cane.
- reduced knockdown angle should reduce soil levels and research is warranted to develop effective gathering of cane without excessive knockdown.

On the field side - development of aids for precision planting at the defined row spacing would be beneficial in reducing soil.

Consideration should also be given to cleaning at the mill to reduce the impact of soil on processing and maintenance costs, and in particular to minimise the impact of peak loadings in wet weather. An automated method of measuring soil in cane levels at the mill would be highly desirable to provide feedback to growers and contractors and a guide to the mill in harvest scheduling following wet weather.

8.0 APPLICATION OF RESULTS TO THE INDUSTRY

The project has identified several avenues for reducing soil in cane levels in the mill and there would be significant benefit to the industry from promotion of measures to reduce soil levels. There has already been significant adoption of variable angle basecutters by one manufacturer, and if these are promoted and used correctly soil levels will be reduced significantly for appropriate field conditions.

The impact of operating speed on soil in cane levels has been highlighted and reduced cutting speeds will have benefits in lower soil levels and stubble damage if suitable incentives are provided for producing a quality product.

The ideal field conditions for minimising soil levels have been clearly defined in this and earlier projects, and continued extension input is warranted to promote improved field preparation for harvesting.

In all situations wet field conditions have an overriding effect on soil in cane levels and techniques for minimising the impact of wet weather need to be put in place. These include selective harvesting of drier fields and low soil hazard blocks after wet weather and delay in the start-up after wet weather. The impact of lost time due to wet weather needs to be clearly defined and weighed against the benefit of reduced soil levels.

9.0 PUBLICATIONS ARISING

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11.0 ACKNOWLEDGMENTS

The author gratefully acknowledge funding support from the Sugar Research and Development Corporation for this project. The cooperation of harvester contractors in different districts in conducting field trials; and of mills in facilitating sampling for soil in cane measurements is also acknowledged. The input of extension staff to surveys of field conditions in different districts together with trial input from Messrs F Chapman, A Benson, L DiBella and D Paton is also gratefully acknowledged. Technical assistance in the project from Mr L Poulsen and Mr K Atkinson provided a major contribution to its success.