BUREAU OF SUGAR EXPERIMENT STATIONS

QUEENSLAND, AUSTRALIA

FINAL REPORT
SRDC PROJECT BS82S

AN INDUSTRY CAMPAIGN TO REDUCE CANE HARVESTING LOSSES

by

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SD97009

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1.0 EXECUTIVE SUMMARY

During 1992-1995 BSES extension staff conducted a major industry-wide campaign to reduce losses associated with harvesting of sugarcane. This referred to cane lost during harvesting operations and cane quality issues concerning extraneous matter and soil in cane supplied for milling. The program followed mounting concern held by the sugar industry and expressed in an industry needs survey conducted in 1990-1991, and considerable experimental evidence of substantial losses.

Snapshot surveys and an intensive trial program were conducted in all sugar centres as an initial step in the awareness phase of the program. Losses were established at 6.5% on a total crop basis, confirming projections established by previous research.

Major contributors to harvesting losses were identified by the surveys and provided a realistic baseline to which to apply targeting techniques developed in a previous SRDC extension methodology program. Demonstration and participatory learning processes were widely employed to foster best harvesting practices and modification of harvester componentry conducive to low losses and high quality cane supply. Additionally, BSES designed improvements to the primary extractor deflector plate on Toft 7000 series harvesters, and to hilling-up boards for shaping cane rows, were used effectively to address cane loss and quality issues.

A structured promotional campaign run in parallel to the projects activities enhanced awareness of harvesting losses and their remedies, and reinforced best harvesting practices.

Evaluation of losses occurred on a continual basis using field survey and monitoring, practices comparison, case study and machinery assessment techniques. Closing survey data showed cane losses were reduced by between 17% and 70% in green cane, and up to 64% in burnt cane operations. Overall, industry losses were reduced by more than one-third of previous surveyed levels. Reduction in harvesting losses of this magnitude had a current estimated value of $38m per annum.

2.0 BACKGROUND

By 1990, great concern was held throughout the sugar industry for losses associated with harvesting. This specifically referred to cane loss, extraneous matter levels and soil in cane supplied for milling. The concern was reflected in the high priority given to harvesting losses in an industry-wide needs survey conducted in 1990-1991.

Harvesting loss research which commenced in the late 1970s, identified substantial loss of cane during harvesting, particularly in green cane. Hurney *et al.* (1984) recorded cleaning losses of 5-8 t/ha in burnt cane and Ridge and Dick (1988) found a wide range of cleaning losses in green cane. Trials with a range of cane varieties in the Tully and Cairns areas showed losses of 4.6% to 18.1%, with the highest losses in trashy, thin-stalked varieties. Shaw and Brotherton (1992) reported an average cane loss of 8.2 t/ha in green cane in the Mulgrave area. In that season, 78% of cane was harvested green in north Queensland.

Research by Ridge *et al.* identified four major types of harvesting loss viz:

(a) extractor loss
(b) boot and elevator loss
(c) pick-up loss
(d) spillage loss

These refer to:

(a) cane thrown from the harvester during cleaning processes
(b) billets falling from the harvester during its operation
(c) cane broken off or run down and not taken into the harvester, and
(d) billets spilt during transfer to haulout equipment and enroute to, or at, the tram siding or road transport systems.

Contributing factors to each type of loss were also identified and their relative importance was established. Some factors were found to be linked and their effects cumulative. The complexity of the inter-related, causative factors meant that the issues needed to be addressed as a whole, as consideration of any factors in isolation was unlikely to impact significantly on overall losses.

The makeup of contributors to harvesting losses is depicted in the following fishbone diagram which suggests also, the many mitigating combinations of loss factors which can operate simultaneously. Similarly, many of these factors influenced soil in cane levels also, providing a double incentive for a holistic approach to harvesting losses.

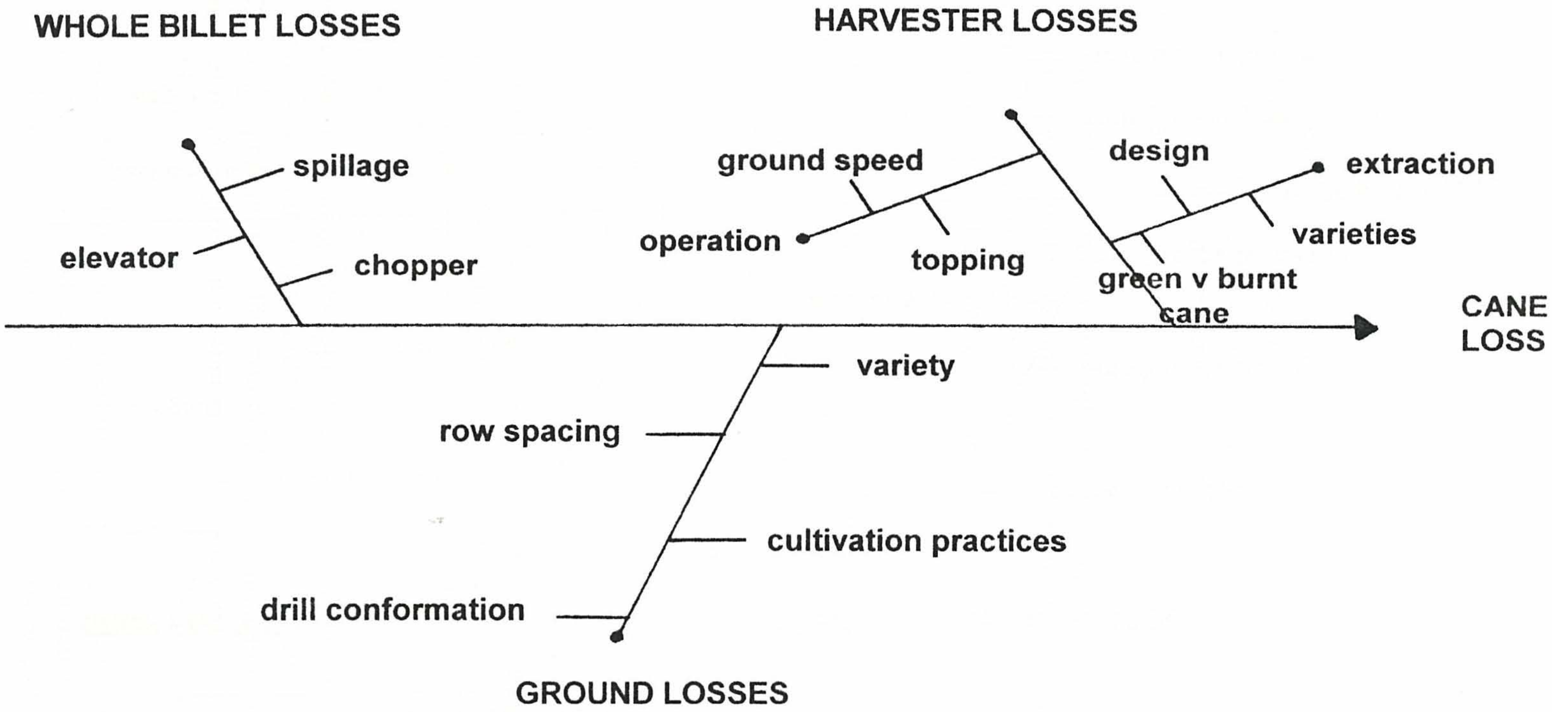
Successful outcomes were reported from SRDC projects BS19S, BS20S, BS26S, BS38S and BS65S. As a consequence several remedial modifications to harvester operation and cultural practices were developed by BSES.

Overall, results indicated that a reduction of 2% cane loss (approximately one-third) below current levels was achievable. A 20% reduction of gross soil levels could also be anticipated by addressing the interactive factors associated with high soil intake by harvesters.

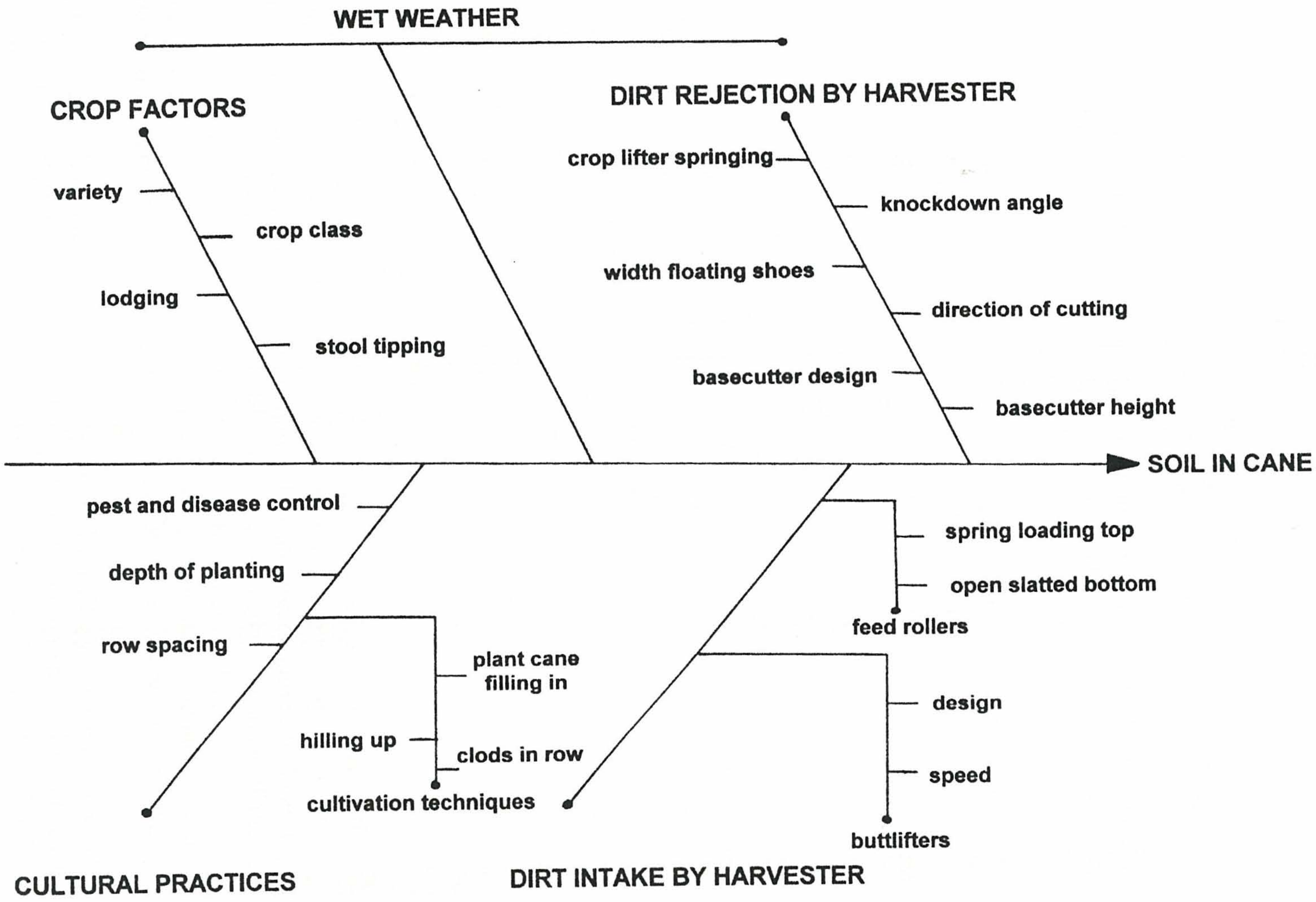
In 1992, gross cane loss during harvesting was estimated at 6.5% of the crop, and was valued at $80m on an annual basis. Soil in the cane supply was causing additional losses conservatively estimated at $15m per annum. The potential savings indicated by research, therefore, were projected at $28m gross per annum and represented an extremely worthwhile and achievable objective.

The BSES extension group was ideally positioned to address these significant issues at an operative level in all canegrowing areas. Extension techniques developed in the SRDC project BS53S provided excellent methodologies to conduct an industry-wide campaign which offered attractive returns for the industry as a whole.

FACTORS CONTRIBUTING TO HARVESTING LOSSES



FACTORS CONTRIBUTING TO SOIL IN CANE



3.0 OBJECTIVES

Project objectives were selected to address general awareness issues and promote adoption of best harvesting practices to achieve industry-wide benefits.

These composed three major objectives:

- Establish a high overall industry awareness of the extent and cause of cane losses during harvesting and soil in the cane supply.
- Educate and motivate those directly involved in harvesting operations concerning modification to harvesting and associated cultural practices, with the aim of reducing harvesting losses by 30% below current levels by 1995 and soil in cane supply by 20%.
- Employ educative and evaluation techniques developed in the SRDC funded extension planning project to achieve these objectives.

4.0 METHODOLOGY

4.1 Extension program

The extension program was designed to operate in four concurrent phases over the 1992 to 1995 harvest seasons:

- creation of industry-wide awareness of harvesting losses
- monitoring and demonstration of harvesting loss, and dirt and extraneous matter problems
- modification of cultural and harvesting practices
- evaluation of the outcomes and impact of such changes.

4.1.1 Phase I - Awareness

A much improved awareness of harvesting losses was achieved by targeting of the three major industry sectors associated with harvesting operations ie management, operations and services. A structured program was conducted in all sugar centres in Year 1 (1992 season) to introduce the project by promotion of widespread understanding of the nature and magnitude of losses, and the opportunities to reduce them. This was aided by the development of a visual promotions kit which summarised research findings, indicated the magnitude of losses, and laid the foundations for adoption of best harvesting practices.

Group educative methodology was widely employed by BSES extension with industry organisations and work groups including Mill Suppliers' Committees and Executives, Cane Protection and Productivity Boards, mill management, cane officers, CANEGROWERS, ASMC, QMCHA, harvesting contractors and operators and growers. Greatest emphasis was directed to growers, harvester contractors and operators where group discussions, focus groups and demonstrations were used effectively to create a high level of awareness.

4.1.2 Survey and monitoring

During phase I a statewide field survey and an intensive experimental program were conducted with the commercial harvester fleet. A total of 334 replicated loss assessments were carried out on a range of varieties and crop types under varying field conditions. The assessments were conducted predominantly with Toft 6000 and 7000 series harvesters, and others such as Camecos which reflected the machines responsible for the majority of the harvest in each centre. This provided an excellent snapshot of current (1992-1993) harvesting losses. Both burnt and green harvest operations were included in the survey to reflect commercial practice.

In addition, 22 replicated trials were conducted at Mossman, Mulgrave/Babinda, Ingham, Proserpine and Bundaberg to focus on the relationship of extractor fan speed to cane loss and extraneous matter, as previous research had shown:

(a) the important contribution of extractor speed to cane loss, particularly in green cane, and
(b) that gains made from reduction of fan speed could easily be negated by rising EM levels.

Field surveys were mainly carried out by assessing primary extractor loss, pickup loss, and billet losses associated with 5 to 10 consecutive runs of the harvester operating under normal commercial conditions. A tarpaulin technique developed by Shaw and Brotherton (1992) was modified with a 5 m tarpaulin being placed beside the row being harvested, aligned with the primary extractor delivery air-stream. Displaced cane material collected from the tarpaulin and each side of the harvested row was related to recovery trials for assessment of extractor loss, and to assess billet and pickup losses.

In some assessments where varying field conditions or treatments applied, comparative yields were used to assess loss differentials. Spillage losses were assessed by relating loss events in the field, at dump points, and at transfer stations to yield and area harvested.

The initial surveys provided a wealth of base data to motivate activity on cane loss reduction, and to reinforce the recommendations from previous research. The surveys provided also, an excellent and active training medium for BSES and productivity staff, and harvesting operators, many of whom had no direct involvement with this work previously. Consequently, this activity initiated the transfer of ownership of harvesting loss problems to the operative sector and provided the impetus for modification of harvesting practices.

4.1.3 Publicity

A structured publicity campaign was conducted in conjunction with the primary phases to create maximum awareness. Mass media and industry communication pathways were employed extensively for this purpose. Newspaper coverage was achieved in local district papers, and interviews were conducted on all levels of rural radio and regional television. Articles were featured in industry publications such as the BSES Bulletin and the Australian Canegrower. Regular updates were employed to reinforce best harvest practices. Papers were presented to the ASSCT Conferences strategically following the main awareness phase, and when evaluation of outcomes was complete.

4.2 Phase II - Demonstration

Demonstration of losses in commercial operations proved a powerful awareness and motivational tool. During Year 2 known contributors to harvesting loss were specifically targeted and remedial options demonstrated. These concentrated on major contributors which had been identified by the surveys and included:

1. primary extractor fan speed
2. deflector plate setting, variable angle options
3. boot and elevator maintenance

The close relationship of extraneous matter to contributors 1 and 2, and the operational adjustments necessary to maintain both acceptable losses and acceptable cane supply quality, were emphasised during this phase.

4.3 Phase III - Best Harvesting Practices

Modification to harvesting and cultural practices was encouraged through targeted demonstration and assessment of major contribution factors. This ensured improved crop presentation which was conducive to a clean, efficient harvest in addition to better harvester settings and operation.

To achieve the best local environment for harvest operations, the following cultural practices were promoted:

- minimum row spacing of 1.5 m
- raised and curved rows 10-15 cm higher than the interspace
- relatively flat interspaces
- absence of ridges on rows and tine marks beside rows
- filling-in and hilling-up of plant cane

Modified hilling-up boards developed for these purposes were demonstrated in most districts. Row forming techniques needed also to address specific requirements of local farming practices such as furrow irrigation and pesticide application.

Harvester modifications were concentrated in three main areas in accordance with the outcomes of the survey and monitoring program:

- control of primary extractor speed
- adjustable deflector plates developed by BSES
- maintenance and adjustment to wear components on chopper assemblies and elevator componentry.

Cane loss monitors (five) were fitted to harvesters in each region for demonstration, monitoring and calibration purposes. It was envisaged that the CLMs would foster a monitoring psyche among harvester contractors and operators, and maintain awareness of losses on a continuous basis.

To facilitate the promotion of best harvesting practices to the operative sector, extension officers received regular updating of harvesting developments, which involved three harvesting workshops.

4.4 Phase IV - Evaluation

Snapshot surveys conducted in Year 1 of the program provided a baseline from which to estimate improvements in harvesting losses through annual monitoring programs. Additionally, replicated trials and field tests conducted in a majority of sugar centres established the relationship of losses to current practices and gave a measure of potential gain from the adoption of best harvesting practices. Final surveys conducted in major cane areas (1995) were concentrated in the same harvesting groups surveyed in 1992 to provide a realistic estimate of change in overall loss.

Data from a large number of case studies were continually assessed also. This provided a tangible assessment of the effect of overall programming and as well a real measure of improvement in major areas of identified loss.

Cultural practices surveys were carried out also to assess their importance as contributors to overall losses.

Comparison of harvester modification between 1992 and 1995 involving componentry conducive to reduction of harvesting loss was used to establish the attention and effort being directed to harvesting losses through harvester improvement.

Professional external reviews were held twice during the course of the project to ensure appropriate methodology was being employed to achieve project objectives.

Illustrating heavy ground loss in burnt Q141 - Bundaberg

5.0 RESULTS AND DISCUSSION

5.1 Initial surveys

The initial statewide surveys confirmed the high losses recorded by Ridge *et al.*, other BSES research and that of other industry researchers and showed average losses 7.4 t/ha in green cane and 3.4 t/ha in burnt cane.

In green cane operations a majority of loss occurred from the primary extraction chamber during the cleaning process. This was due mainly to excessive fan speed and was confirmed repeatedly in the replicated trial program. Other causes such as high or inappropriate deflector plate settings, incorrect fan clearances and non-standard fans were also identified to a lesser degree.

In burnt cane, ground losses contributed most to total losses; extraction loss was minor and found acceptable in a majority of tests. Ground loss was closely related to crop condition and variety. Lodged or badly sprawled crops meant increased ground losses; brittle varieties demonstrated serious ground loss eg Q141 at Bundaberg which suffered lower losses in green cane operations, contrary to other varieties.

Although significant on occasion, billet loss did not prove a major contributor to total loss and was usually associated with poorly maintained harvesters and rough alignment of bin-out units with harvesters and bins at sidings.

A summary of the initial survey is given in Table 1. Losses were substantial in all districts except the Burdekin, especially in green cane operations. A disturbing feature of the data was the high proportion (30%) of tests showing losses in excess of 8.0 t cane/ha, and with 11% tests greater than 12.0 t cane/ha. The data confirmed serious losses throughout the industry and indicated that a significant proportion of harvesting events were so wasteful as to reduce profitability to marginal levels.

Varietal characteristics influenced loss levels to varying degrees. At Bundaberg, where a stratified survey reflected variety percentages and crop type, large differences were indicated between varieties (Table 2). Data also showed that make-up of harvesting loss was influenced by variety (Table 3).

Factors such as crop condition and direction of harvest, row profile, ground preparation and row spacing also affected overall loss.

TABLE 1

Summary of regional harvesting loss surveys - (1992-1993)

Region	Varieties	Cane loss t/ha		No. of tests***	Green/ burnt
		Extractor*	Total		
Far North Mossman-Tully	Q96,Q107,Q113,Q115,Q117, Q120,Q122,Q124,Q130,Q138 H56-752	7.0	**	74	G
Herbert	Q115,Q117,Q124,Q128, Cassius	7.7	8.3	16	G
Burdekin	Q96,Q117,Q133	0.6	0.8	24	B
	Q96,Q117	3.0	3.4	18	G
Central Proserpine-Plane Creek	Q124,Q135,Q136,CP44-101, H56-752	1.5	2.5	31	B
	Q124,Q135,Q136,H56-752	5.9	6.6	39	G
Bundaberg	Q110,Q141,Q146,Q150, CP44-101,CP51-21,H56-752	2.0	5.4	47	B
	Q141,Q146,CP51-21,H56-752	6.0 (2.5)	6.7	29	G
Far South Isis-Rocky Point	Q95,Q110,Q137,Q143,Q145, Q146,Q147,CP44-101,CP51-21,H56-752	1.9	4.1	42	B
	Q137,Q141,Q147,CP44-101,CP51-21	5.8	8.3	14	G

* *Extractor loss assessments include a recovery factor. The bracketed figure for Bundaberg corresponds to trials where both total loss and extractor loss were measured.*

** *Assessments in the Far North concentrated on extractor loss (green cane) as the major contributor to total cane loss.*

*** *A standard test involves 5 replications in adjacent rows or at random throughout the field.*

TABLE 2

Effect of variety on total cane loss
Bundaberg - burnt cane

Variety	Total cane loss tonnes cane/ha
Q141	8.6
Q146	6.8
CP51-21	4.1
CP44-101	4.3
H56-752	3.8

TABLE 3

Effect of variety on type of harvesting loss
Bundaberg - burnt and green cane

Variety	Pick-up loss (% of total loss)	Primary extractor loss (% of total loss)	Other
Q141	73	24	3
CP51-21	45	45	10
Q146	58	35	7

The surveys achieved a number of specific outcomes, viz:

- a complete industry assessment of the magnitude of harvesting losses
- identification of the major contributing causes of loss, and a reasonable delineation of these on a district basis
- confirmation of a large potential for improvement in a majority of sugar districts
- training on loss assessment, identification and remedial methodology for BSES and productivity staff
- transfer of ownership of harvesting losses to the operative sector.

5.2 Replicated trials

Assessments provided by the surveys were strongly supported by results of the 22 replicated trials. In green cane operations, cane loss was linked directly to fan speed in the primary extraction chamber. High fan speed caused unacceptable losses in a majority of trials, while low speeds led to high levels of extraneous matter. Adjustment of primary extractor speed to between 1 200 and 1 300 rpm resulted in acceptable levels of cane loss and extraneous matter, providing best returns for all major industry stakeholders. This relationship was demonstrated repeatedly in trials and field assessments regardless of variety or crop type and condition as illustrated in the trial summary given in Table 4.

TABLE 4

Relationship of primary extractor speed to cane loss and extraneous matter (EM) levels - replicated trials

District - green or burnt cane	Extractor speed	Cane loss t/ha	EM%	No. of trials
Ingham - green	1 000	2.1	10.2	3
	1 200	3.4	9.1	
	1 400	7.6	7.5	
Mossman - green	1 050	1.2	5.6	6
	1 250	2.1	4.4	
	1 450	5.2	3.5	
Mulgrave - green	1 025	1.0 *	15.6 *	4
	1 200	6.4 *	12.3 *	
	1 425	15.0 *	10.9 *	
Proserpine - green	1 000	1.0	10.8	3
	1 250	1.2	8.7	
	1 450	8.4	7.7	
Proserpine - burnt	1 000	0.6	6.6	3
	1 250	0.9	5.2	
	1 450	3.1	3.7	
Bundaberg - green	1 000	0.8 *	10.7 *	3
	1 200	5.4 *	8.2 *	
	1 425	12.3 *	7.4 *	

**Note: Some of these trials were conducted specifically with high loss varieties*

5.3 Harvester componentry

A high-angled trajectory of cut cane from the chopper box into the primary extraction chamber was identified as a significant factor in extraction loss in the Toft 7000 series harvesters. In one model where a larger fan motor had been introduced, losses were extreme. Excellent control of the cane trajectory was achieved by siting a low-cost adjustable flap on the deflector plate. This allowed sufficient extraction of extraneous matter and maintained acceptable loss levels.

Identification and targeting of contributing factors through demonstration and monitoring proved highly effective in achieving change to harvester componentry, settings and operation. Media coverage aided this process by reinforcing the methodologies and highly positive outcomes (see appendices). The effectiveness of targeting is best illustrated by 48 case studies (Table 5) which recorded average reduction of harvesting loss of 68%.

TABLE 5

Summary of case studies illustrating effectiveness of targeting and range of reductions in harvesting losses (1993-1995)

Harvester modifications	Cane loss t/ha		Reduction range % (average)	No. of case studies
	before	after		
Fan speed reduction - primary extractor (mainly green cane)	10.9	3.8	19-90 (65)	21
Modification to deflector plate	12.3	4.3	7-91 (65)	17
Modification to extractor componentry	6.4	2.0	25-89	5
Sundry elevator and chopper repairs	9.0	0.5	89-99	5

5.4 Assessments

Data comparing 1992 assessments with those conducted in 1995 show that losses were reduced by between 17% and 70% in green cane, and by up to 64% in burnt cane operations. Table 6 summarises these comparisons over five diverse sugar regions. The data indicates that total losses were reduced by 2.5% ie in excess of one-third of previous losses. On 1995 sugar values this represents a gross improvement in income of $38m per annum.

Most improvements in green cane occurred through reduction of extractor loss (Table 7). This trend was contradicted at Bundaberg probably because of very different crop conditions in 1992 and 1995 and a 115% increase in green cane harvesting.

Major improvements to harvester componentry which provide better management of cane loss had a marked impact upon these outcomes. Assessments of changes to the harvester fleet 1992-1995 indicate that substantial improvement to components related to cane loss had occurred in:

(a) the primary extraction chamber
(b) to the deflector plate
(c) basecutter, and
(d) topper

TABLE 6

Total losses surveyed in 1992 and 1995 in green and burnt cane

Area	Harvesting loss (t cane/ha)			
	1992		1995	
	cane loss	EM%*	cane loss	EM%
Green cane				
Mulgrave/Babinda#	10.5	9.1	3.1	N.A.
Tully	6.4	8.9	5.3	9.4
Ingham	8.3	N.A.	4.2	7.3
Mackay	8.6	7.9	4.4	9.5
Bundaberg	4.7	7.8	3.7	6.9
Burnt cane				
Tully	4.4	7.9	5.6	6.9
Mackay	2.5	5.4	0.9	6.9
Bundaberg	5.6	N.A.	2.5	5.9

** Replicated trial data*
 # Far northern surveys concentrated on extractor loss

TABLE 7

Changes in primary extractor cane loss surveyed in 1992 and 1995

Area	Cleaning losses (t cane/ha)	
	1992	1995
Green cane		
Mulgrave/Babinda	10.5	3.1
Tully	5.0	3.7
Herbert	7.7	3.6
Mackay	8.1	4.1
Bundaberg	2.5	3.1
Burnt cane		
Tully	2.0	1.5
Mackay	1.5	0.9
Bundaberg	1.8	0.3

Significant changes had occurred also to the secondary chamber, chopper box, hydraulics, feed rollers, buttlifter, knockdown roller and floating shoes. Most positive change had occurred through purchase of new harvesters, and reflected an improved effort by manufacturers to address harvesting loss issues. Table 8 illustrates similar trends in a majority of sugar regions, although differences exist between regions as to the level of adoption/introduction of various improvements.

Cane loss monitors proved useful aids for establishing operational specifications such as extractor fan speed and ground speed. However, the systems were prone to damage during harvesting and servicing was difficult or impractical. This limited their use and their potential as a primary aid to control harvesting losses was not realised.

5.5 Cultural practices

Cultural practices which predispose high cane loss levels and increased soil in the cane supply were identified as significant contributory factors in several districts. Assessments of row spacing and drill shape indicated considerable potential for avenues of low-cost improvement of crop presentation for harvest (Table 9). Despite average row spacing improving progressively, there was increasing evidence of high variation of row-to-row spacing. Poorly filled plant drills and flat drills were common contributing factors, as was a twin-ridged effect created by late filling-in operations in plant cane. Local practices exacerbated problems as experienced with delving irrigation furrows just prior to canopy closure.

The use of adjustable hilling boards which shaped both row and interrow, reduced these problems substantially. This approach was both practical and low cost; twin boards (ie two interspaces) were supplied by local manufacturers for $250-$280. This aspect of counteracting harvesting losses deserves more detailed research and requires proactive extension throughout the sugar industry.

TABLE 8
Percentage adoption of changes in harvester components related to cane loss, 1992 and 1995

Region	Year	% adoption of changes											
		deflector plate modif	hydraulics	2° extract	1° extract	chopper	feed rollers	buttlifter	basecutter	knockdown roller	floating shoes	gath spirals	topper
Bundaberg	1992	11	6	0	0	22	17	22	33	6	6	6	6
	1995	78	44	22	61	67	61	39	72	22	11	0	89
Burdekin	1992	9	9	9	9	0	0	0	0	0	0	0	9
	1995	45	45	73	64	36	55	27	55	18	18	18	55
Innisfail	1992	20	33	20	33	13	20	33	67	27	20	33	27
	1995	67	53	47	73	47	40	53	60	33	20	47	40
Mackay	1992	37	5	5	11	0	5	5	16	11	0	32	11
	1995	68	47	53	84	21	37	21	37	32	0	53	53
Ingham	1992	17	33	0	33	0	0	0	17	33	17	0	0
	1995	83	83	0	100	67	0	33	50	50	33	33	33
Tully	1992	12	38	12	27	15	23	31	46	31	8	88	23
	1995	81	46	15	54	15	23	31	85	31	8	38	69
Weighted mean	1992	18	21	8	18	11	14	19	34	18	7	37	15
	1995	72	49	35	68	37	38	34	63	29	12	33	61

TABLE 9

Assessment of suitability of row spacing and row shape

Cultural practices surveys - plant cane 1992-1993		
Region	**% inadequate row space**	**% poor drill shape**
Far North	<10	61
Burdekin	1	13
Central	49	65
South	28	72

5.6 Soil in cane

Contamination of harvested cane by soil was linked directly also to harvester settings and operation. Increased basecutter angle reduced soil retention where high row profiles exacerbated other factors such as cutting depth. Trials conducted in the Burdekin with the Cannavan variable-angle basecutter modification reduced soil levels substantially when maximum angle (17°) was applied over high-hilled rows (Table 10). Similar results were achieved in the wet tropics with domed basecutters (Table 10a) which increase blade angle and appear to shed more soil during operation. Initial data indicate variable angle basecutters should be investigated further, as this modification would help cater for the wide range of row profiles encountered at harvest.

TABLE 10

Effect of basecutter angle on soil levels
Burdekin - high row profile

Setting	Replicate	Mill dirt reading	Ash % cane BSES	CCS
17°	1	1	1.35	13.3
11°		2	2.11	13.1
17°	2	1	0.94	13.2
11°		2	2.04	13.0
17°	3	1	1.34	13.2
11°		1	1.94	13.2
17°	4	1	1.34	13.2
11°		2	2.23	13.1
Mean 17°		1.00	1.37	13.23
Mean 11°		1.75	2.09	13.10
lsd 5%		0.8 (ns)	0.41	0.15 (ns)

TABLE 10a

Soil levels
domed vs flat basecutter

Basecutter type	Soil content	
	Ash % cane*	Soil % cane#
Domed	1.44	0.8
Standard	2.68	3.0

* Mossman
# Tully soil monitor

Ground speed was identified as a major contributor to high soil levels. Low to moderate soil levels were recorded in north Queensland trials at normal operational speeds with levels worsening steadily with increased ground speed (Tables 11, 12, 13). Where increased speed was coupled with lower basecutter settings, soil levels rose sharply demonstrating a strong cumulative effect (Table 12). Extraneous matter levels were similarly affected by operational speeds. The data showed repeatedly that where ground speed was excessive, highly significant soil levels could result, especially if row profiles were unsuitable. The data, collectively, suggest that ground speed is excessive in many harvesting events and often exceeds the harvesters capacity to produce a quality product.

The trend to increased harvesting speed requires close industry scrutiny for fear of a steadily worsening quality of cane supply.

TABLE 11

Effect of harvester operation on soil levels in cane

Harvester operation	% soil	
	South Johnstone	Babinda
Ground speed		
Fast	2.62	1.42
Slow (N)	2.56	1.46
	NS	NS
Basecutter height		
High (N)	2.80	
Low	4.85	

N = normal

TABLE 12

Effects of harvesting speed and cutting depths on soil levels in cane Tully

Cutting speed range kph	Range in soil levels %
3.2 - 4.7	6.6 - 8.8*
3.2 - 4.7	0.0 - 0.8**
6.6 - 8.6	1.3 - 2.0**
7.4 - 9.3	2.0 - 2.9**
7.2 - 9.2	1.5 - 2.7**

* cutting depth 6-8 cm
** cutting depth 0-2 cm

TABLE 13

Effects of cutting speed on extraneous matter and soil levels in cane Tully

kph	EM%	% soil
5.0	2.7	2.4
7.7	3.7	2.6
9.5	7.4	3.0

6.0 ADDITIONAL FINDINGS

Survey and trial data suggested that harvesting losses posed implications for some associated issues.

Pest control

Observations in north Queensland indicated that cane weevil borer activity and carryover was related to harvesting loss levels. Larger pieces of 'lost' cane - billets, solid tops, large shredded pieces, rundown stalks - provided additional carryover hosting sites for this pest leading to increased damage in following crops (Robertson and Webster 1995). With a majority of cane harvested green in north Queensland, harvesting losses incur an additional dimension in borer prone localities.

Trial yields

The propensity for some varieties to suffer greater loss than others suggested that measured yields in trials may be biased by harvesting losses. Assessments of two replicated variety trials demonstrated this effect (Table 14) but there was no significant change to the rank order of varieties. However, high potential loss in a standard variety eg

Q141 in burnt cane at Bundaberg, could be problematical if treatment differentials were lower than, or similar to, harvesting loss levels.

TABLE 14

Losses associated with variety trials - Bundaberg

Varieties	Yield t cane/ha	Losses t cane/ha	Ranking	Adjusted ranking
Trial 1 - Burnt		*		
CP51-21	85.66	3.77	5	5
77S1321	100.66	4.25	4	4
84S818	115.33	3.36	3	3
77N330	134.33	2.50	2	2
88S7335	136.66	4.79	1	1
Trial II - Green		#		
83S2159	75.00	1.31	7	7
Q141	98.49	2.77	6	5
83S1048	99.48	1.03	5	6
83S2103	103.58	0.93	4	4
84S2504	114.52	1.14	3	3
87S7364	121.78	1.42	2	2
85S1075	126.73	1.03	1	1

* Total loss
\# Extractor loss

A dynamic harvesting scene

Revisiting growers, harvesting groups and contractors during 1992-95 seasons showed that many changes took place year to year, not only with harvesters and associated equipment, but with operators also. This meant that improved practices and harvesting componentry established during one season were not necessarily continued in the next. Of particular concern were modifications to harvesters (manufacturers and contractors) which increased specific types of loss, and the return by operators to practices which had been previously corrected or improved with a different harvester or operator.

Characterisation of new model harvesters was essential to maintain the improved results already achieved, and continuing education of operators was an obvious necessity. This has particular implications for the industry given the regular replacement of harvesters, increased competition between manufacturers currently leading to increased innovation and modification, and apparently high operator turnover.

7.0 PROBLEMS ENCOUNTERED

Scepticism and non-acceptance of the magnitude of losses were encountered on a number of occasions mainly with contractors and operators, and some growers. This was successfully counteracted by group demonstration and monitoring exercises, confirming the value of this oft-applied extension methodology. Some delays were experienced however in achieving transfer of ownership resulting in slow initial progress in a number of sugar districts.

The extreme diversity of the harvesting fleet posed specific difficulties. Additionally, the many operational variables encountered confused direction for remedies until sufficient survey and trial data had been accumulated. Major issues could then be identified and appropriate targeting strategies employed. These difficulties had also a positive effect in providing an excellent training background for staff.

Year to year changes in crop and field conditions, harvesters and allied equipment, introduction of new makes and models, changing harvester componentry, increasing power availability and myriad harvester modifications created a strongly dynamic harvesting scene. The significant turnover of operators magnified problems associated with this and necessitated a constant reaffirmation of the major issues and adherence to the targeting strategies selected from the monitoring program. It became evident that continual updating and training of operators was essential for the maintenance of good harvesting practices.

The scarcity of extraneous matter testing facilities at a majority of mills, especially systems to measure soil in cane, made these assessments very difficult or impossible in most mill areas. Meaningful soil data was available only at Tully; this supported recommended best-practice cultural and harvesting practices as effective methods of reducing soil in cane levels, but could not be used for assessment of overall industry benefits.

8.0 RECOMMENDATIONS

(a) Regular monitoring of harvesting losses should occur. Timing of monitoring programs could reflect district problems but should be conducted on an industry basis at least every five years.

(b) Reaffirmation of best-practice harvesting procedures should occur prior to and/or during each harvest. Cane loss x extraneous matter relationships should be emphasised during these awareness exercises.

(c) Further research concerning harvester limitations is imperative and urgent. Operational speed x pour rate x cleaning efficiency relationships stand out as an area requiring improved definition of operational standards.

(d) Investigation of the effects of variable basecutter angle upon soil levels, cane loss, and ratooning should continue and intensify.

(e) Training of contractors and operators requires upgrading. Consideration should be given to making harvester operation a ‘licenced’ position in the long-term. Annual refresher courses are recommended especially where new or modified machinery is involved. Additionally, researchers, extension officers, field supervisors and cane officers should be updated at two-year intervals.

(f) Close cooperation with harvester and harvesting equipment manufacturers should be fostered. Full disclosure of non-confidential information, concerns, recommendations and remedies is recommended.

(g) BSES extension should commence a major program in all districts to address the issues of unsuitable and uneven row spacing, and improperly shaped rows.

(h) Harvesting losses should be a substantive criterion applied in new variety selection.

9.0 APPLICATION OF RESULTS TO INDUSTRY

All facets of harvesting loss encountered had overall industry application and will retain this in principle in the near and medium term. Strategies to address losses, however, will require updating as harvester componentry and cultural practices change.

The methodologies employed in the project are demonstrably suitable for addressing industry-wide issues. In particular, the integration of proactive and reactive extension activities has wide appeal for rapid technology transfer as well as providing immediate assessment of outcomes and their impact. Even wider application of these methodologies is probable with modification to scale.

10.0 TECHNOLOGY DEVELOPMENT

No technology development or intellectual property issues are associated with the project.

11.0 PUBLICATIONS ARISING

Two detailed papers were published in the Proceedings of the Australian Society of Sugar Cane Technologists, the latter earning the Presidents medal in 1996.

1. Linedale, A I, Ridge, D R, and Chapman, F L (1993). A coordinated extension approach for maximising returns from mechanical harvesting. Proc. Aust. Soc. Sugar Cane Technol., 1993 Conf., 45-41.

2. Linedale, A I and Ridge D R (1996). A successful campaign to minimise harvesting losses within the Queensland sugar industry. Proc. Aust. Soc. Sugar Cane Technol., 1996 Conf., 1-5.

Several articles were published in the BSES Bulletin by the project supervisors and individual extension officers during the course of the project.

12.0 REFERENCES

Hurney, A P, Ridge, D R and Dick, R G (1984). Evaluation of the efficiency of cane harvesters in removing extraneous matter and in limiting cane losses during the cleaning process. Proc. Aust. Soc. Sugar Cane Technol., 1984 Conf., 11-19.

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13.0 ACKNOWLEDGMENTS

The successful outcomes and significant financial impact of this project were due, largely, to the collective efforts of the BSES extension staff, and associated productivity staff, and the task force charged with program coordination viz:

David Calcino	-	Far North and Herbert
Fraser Chapman	-	Burdekin and Central
Peter Downs	-	Southern
Ken Atkinson	-	Technician
Les Poulsen	-	Technician
Ross Ridge	-	Technical support
Tony Linedale	-	State coordination and NSW liaison

Cooperation of the operative sector, especially harvester operators, is gratefully acknowledged. Particular acknowledgment is made of Chris Cannavan, Ayr for development of the variable angled basecutter.

The project was jointly funded by BSES and SRDC.

APPENDICES

APPENDIX 1

Modification cuts losses in older cane harvester

2.11.93 Bush Telegraph

AN exercise to look at reducing cane losses in older model harvesters has proven successful in the Plane Creek mill area.

Productivity program co-ordinator of the Productivity Enhancement Committee, Mr Bill Webb said substantial research into cane loss had been conducted on newer harvesters, in particular Austoft 7000s with rotary chopping mechanisms, but growers had asked for older models to be looked at.

He said with the assistance of Bundaberg based BSES technician, Mr Ken Atkinson, a Plane Creek grower and productivity enhancement program staff had succeeded in reducing, almost to zero, cane loss from the secondary extractor of a swinging knife Toft 6000.

"The modification is simple, cheap, easy to install, and, most importantly, effective," Mr Webb said.

A spacer, was placed between the end of the elevator and the secondary extractor unit.

The aim was to extend the the extractor 300mm further from the end of the extractor, and raise the extractor by 150mm while maintaining its angle to the horizontal.

Mr Webb said the modification resulted in less chance of whole billets being "flicked" into the extractor and lost.

There is also more time and distance for cane and trash to separate before entering the air stream, resulting in more efficient cleaning with the reduced cane loss.

The extractor is higher in relation to the elevator and reduces the opportunity for billets to be "sucked" out with trash.

Billet damage (bruising) is reduced as billets have further to travel and lose speed before contacting the extractor shroud or directing flap.

Mr Webb said it was necessary to extend the length of the directing flap by using rubber to prevent billets missing the bin as their new trajectory through the air caused them to miss the standard flap.

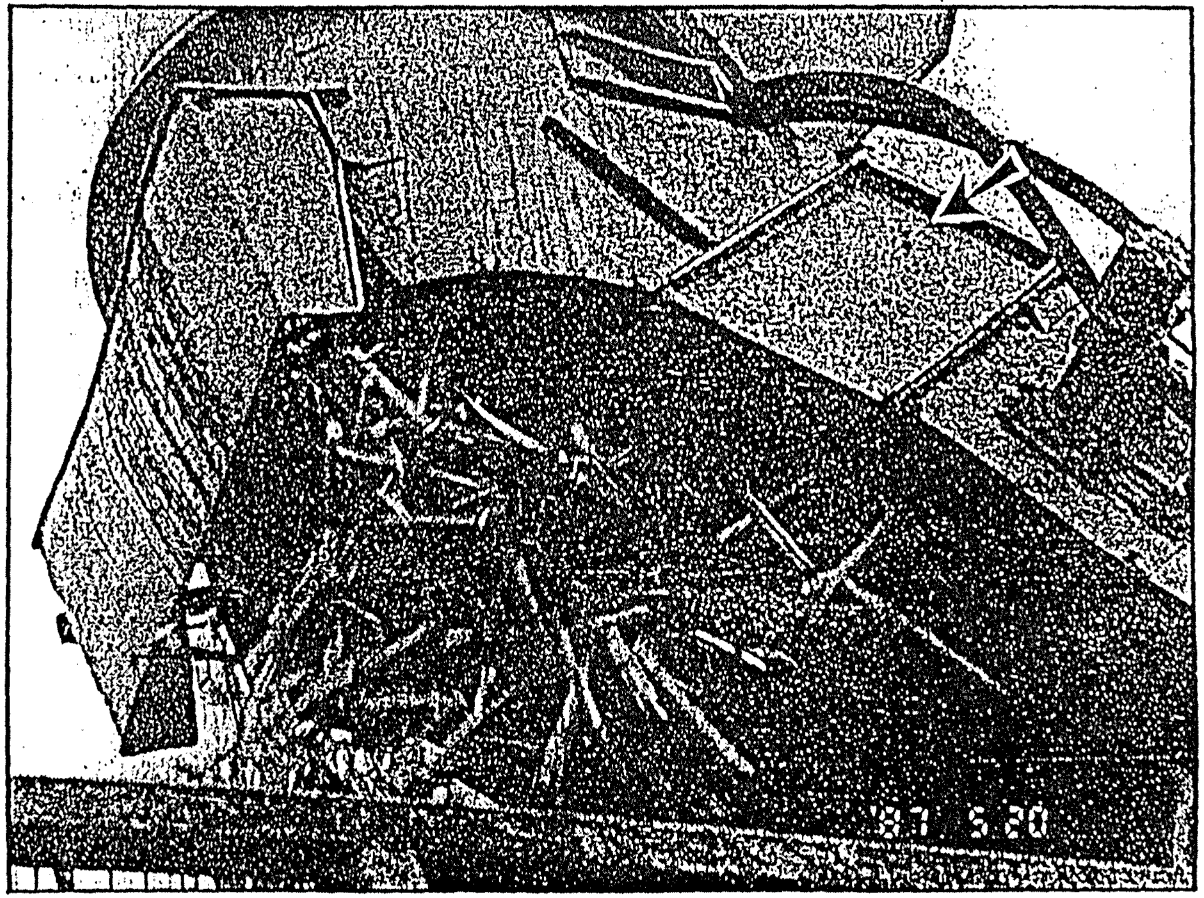
He said the modified machine was fitted with a plastic shroud so the possible effect of the modification on the harvester stability was not noted due to the reduced weight of the shroud.

Mr Webb said the modification had been applied to machines in the other mill areas of the Mackay district.

He said it may have application on other and/or older machines.

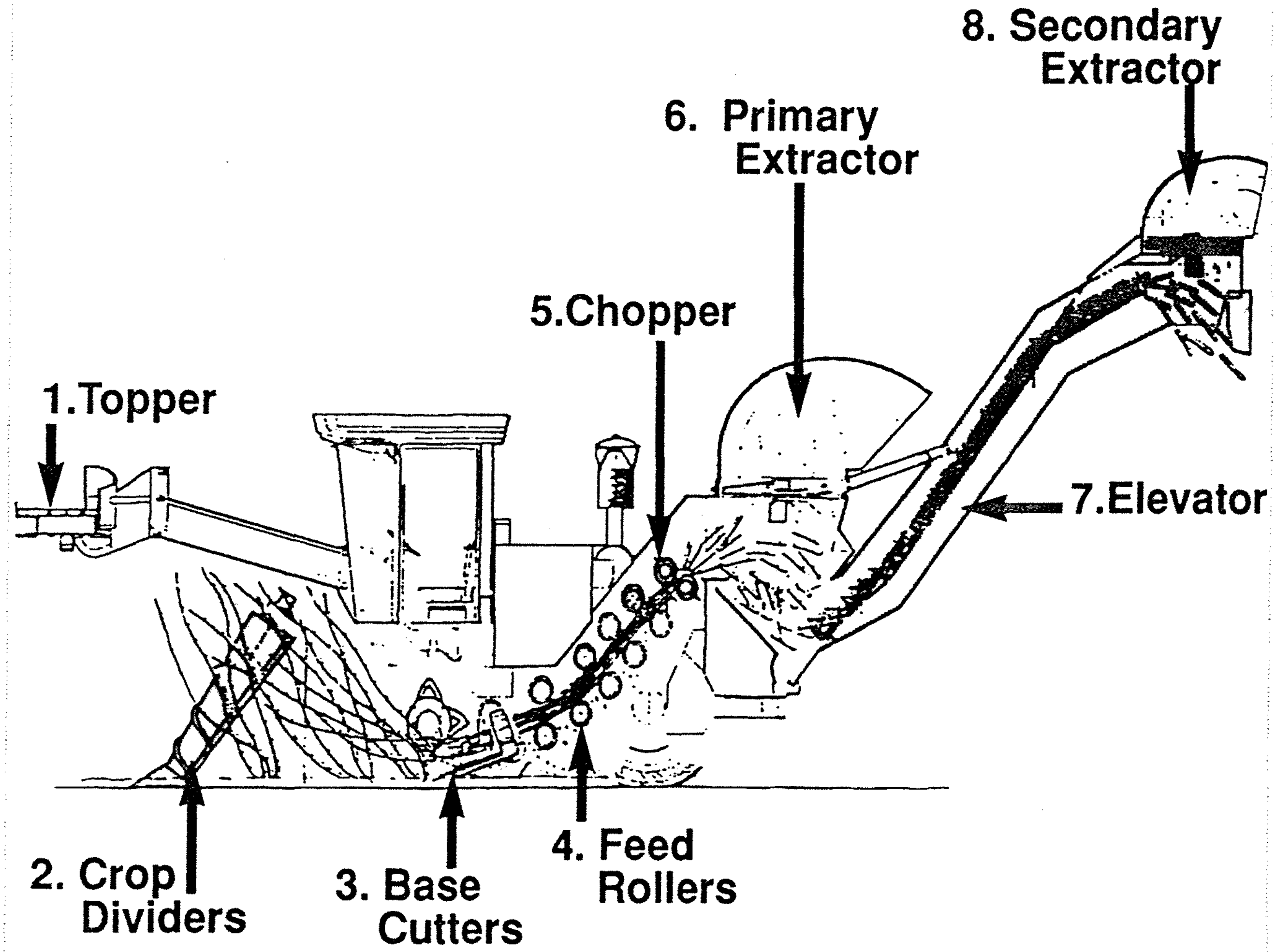
Diagram P 2

Bus tour P 2.



THE arrow shows where the spacer was added to the elevator of a swing knife Toft 6000 harvestor. The template for the modification is available for growers to inspect.

MINIMISING CANE LOSSES



Illustrating the eight main points of cane loss on a modern harvester

BSES

MINIMISING CANE LOSSES

Major cane losses include:

- extractor loss
- boot and elevator loss
- pick-up loss
- spillage loss

Minimising extractor loss

- burn high loss varieties where possible
- use correct extractor blade tip clearance

    * cross arm extractor - minimum 25 mm
    * vertical arm extractor - minimum 40 mm

- adjust deflector plate

    * lengthen by 75-100 mm
    * lower by approximately 20 mm

- adjust primary extractor speed (1200 mm extractor)

    * optimum in green cane is 1250-1300 rpm for minimal cane loss, satisfactory extraneous matter levels
    * optimum in burnt cane 1300-1350 rpm

Option 1

- fixed speed change ring on motor

Option 2

- variable speed. Fit variable stroke piston pump and fixed displacement piston motor with cable, hydraulic or electronic controls. Brands - Sunstrand, Hagglund Denison, Eaton. Fit extra suction filter or upgrade existing filter.

- Fit a bleed valve between existing pump and extractor motor. Preferably pressure compensated. Return oil should be fed into top of hydraulic tank. Note that it may be desirable to fit extra oil cooling if hydraulic oil temperature is high. **Warranty on new machines may be void with bleed valve.**

The Cane Loss Monitor is a valuable aid for setting extractor speeds and monitoring cane losses.

- raise extractor height by fitting an extension ring below the extractor. Height needs to be raised by 300 mm or more.

  Note: if elevator speed has been increased for green cane harvesting a proprietary spacer may be needed under the secondary extractor fan to reduce cane loss.

> In all cases where modifications have been made to reduce cane loss extraneous matter will increase. A correct balance needs to be reached between cane loss and extraneous matter levels to maximise bin weights and minimise processing losses in the mill.

Boot and elevator losses

Boot losses can be minimised by the use of chains around the edge of the boot if losses appear excessive.

Elevator losses through spillage can usually be eliminated by slowing cutting speed or speeding up the elevator chain.

Carryover under the elevator slats can be minimised by regular maintenance of wear strips or installation of adjustable sprockets at the elevator bends. The bottom bend of the elevator is the most important.

Pick-up losses

These are primarily due to poor drill shape and size for harvesting, tine marks beside the row or tramping of cane by the harvester wheel due to narrow row spacings. Minimum row spacing of 1.5 m with slightly rounded drills 10-15 cm above a flat inter-row are recommended. In brittle varieties cutting green can reduce pick-up losses.

Spillage losses

Spillage losses are generally caused by overfilling of bins, lack of care during tipping or elevating cane into mill bins, poor equipment design causing spillage at the points or poor approaches to the points. Care and cooperation at all stages of the harvest operation should minimise spillage.

MINIMISING CANE LOSSES

A Check List of Methods of Reducing Dirt in the Cane Supply

IMPROVED FIELD CONDITIONS

- ☑ Later start after wet weather
- ☑ Improved cultivation practices
- ☑ Non lodging/stool tipping varieties
- ☑ Deep planting and hilling up
- ☑ Improved pest control
- ☑ Wider row spacings

IMPROVED HARVESTER DESIGN

- ☑ Spring loaded croplifter spirals
- ☑ Narrow based floating sidewalls
- ☑ Reduced cane knockdown angle
- ☑ Scalloped basecutter discs
- ☑ Slow buttlifter roller
- ☑ Open slatted bottom feed rollers
- ☑ Spring loaded top feed rollers