A TRIAL TO COMPARE CORE SAMPLING WITH THE FULL WIDTH HATCH METHOD OF CANE SAMPLING

By M. A. BROKENSHA
Sugar Industry Central Board

Keywords: Cane sampling, Core sampler, Hatch sampler

Abstract

Core sampling using the single barrel overhead inclined corer has been compared with the full width hatch method of cane sampling. Core sampling precision taking 3 cores per vehicle load was found to be considerably poorer than hatch sampling and there was evidence of bias when extraneous matter was present. However, the magnitude of the differential bias was generally small. Capital and operating costs for the core sampler are higher than for the full width hatch sampler.

Introduction

In the South African sugar industry, sampling of prepared cane via the full width hatch sampler[1] is the official method of sampling for cane payment. The full width hatch sampler is positioned at the end of the cane carrier immediately prior to the cane feed into the extraction plant and as such, is situated some distance downstream from the cane receival point at the mill. As a consequence, mill yard cane handling procedures are constrained to a considerable extent because individual grower identity of the cane loads has to be maintained up to the cane sampling point.

The new Felixton II sugar mill incorporates features in the cane yard off-loading and cane preparation systems that are designed to give optimum efficiency and cost savings. However, there was concern that these features would give rise to intermixing of adjacent cane loads on the carriers to the extent that it would be difficult to differentiate between the cane from different suppliers as it passed the full width hatch sampler. Core sampling permits sampling of the cane in the delivery vehicle and therefore intermixing of cane after offloading is not of concern with this method.

Accordingly, in June 1982, the Council of the South African Sugar Association (SASA) agreed that the Central Board Cane Testing Service (CTS) should conduct an extensive examination of core sampling with the view to its possible implentation at the new Felixton II sugar mill. This investigation was conducted during the 1982/83 season under the direction of a SASA appointed Technical Sub-Committee.

Equipment

Core sampling equipment

Core sampler: The Felixton II mill is designed to handle cane which is delivered in Hilo road vehicles and SAR trucks — both are large capacity vehicles each carrying more than 18 tons cane. For these transport modes, the overhead inclined form of core sampler was considered to be most suitable and a single barrel sampler, similar in design to that described by Ashe,[2] was constructed for the trial. However, unlike the model described by Ashe in which the barrel lifts up before discharging the sample, the later model discharges directly into a screw conveyor without first lifting the discharge end into position. This permits the travelling carriage system to be located at four points (via locating bearings) instead of only two as in the case of the earlier model, making for greater stability and smoother operation during coring.

The overhead corer is inclined at an angle of 45° to the horizontal and from the retracted position the rotating barrel (500 rpm), fitted with a crown cutter, moves down a slide for a total travel of 5 metres. Speed of travel is 10 metres/minute and depth of penetration into the cane bed is to within 400 mm of the vehicle's main floor level. To increase cane carrying capacity there is a recessed section in the centre of the vehicle and cane in this section was inaccessible to the corer. After retraction, the cane core (± 13 kg) contained within the barrel is ejected via a piston into a screw conveyor which transfers the sample to the cane preparation equipment.

Initially, the crown cutter was made of heavy gauge (7 mm thickness) 200 mm diameter tubing containing 16 large, rather coarse teeth (45 mm long) which were splayed with a 3 mm set. It failed to cut cleanly and tended to sever the billets with a mangling, twisting action. Trash tended to be dragged into the sample from the surrounding cane. The crown cutter was replaced with a unit consisting of a rolled band saw (3 mm thick) containing much smaller and finer teeth (12 mm pitch; 12 mm deep) with no set. Its cutting action was found to be considerably better, but twisted severance of billets and balling of trash was still detected.

Hippo mill: The particle size of the sample taken by the corer had to be reduced for efficient sub-sampling. For this purpose, a Hippo mill (Model 69) was positioned at the end of the screw conveyor leading from the corer discharge point.

Initially, problems were experienced with the Hippo mill. The orifice plate frequently choked; strong up-draught windage existed and finely prepared cane tended to build up in large amounts on the internal walls of the machine. On the other hand, the degree of preparation was excellent. Following numerous trials with various types and sizes of screens, a reasonable compromise was obtained by removing the screen and repositioning the washboard between the 3 and 5 o'clock positions. The base of the drum was fitted with a solid plate containing one large, 150 mm diameter aperture.

Sub-sampler: From the Hippo mill the cane passes through a two stage sub-sampler of similar design to that described in the Laboratory Manual for South African Sugar Factories. The sampler used in the trial required careful tuning to give a representative sub-sample of the stratified core sample. Stratification of the sample commences at the corer since the core sample is usually taken diagonally across the bundle of cane giving rise to a stratified sequence of butts, middle-stalk and tops within the barrel. This stratification is retained through the Hippo mill and hence through the sub-sampling system and even into the sample receiving bin. To overcome this requires a far greater degree of tuning than is necessary with prepared cane taken via the full width hatch — in this latter case the cane has been thoroughly prepared and very well mixed.

Both flip-flaps were set to operate at maximum cut frequency (2 seconds accepted/2 seconds reject). Proper bulking up of the feed to the second flip-flap was achieved by reducing the speed of rotation of the screw conveyor from 50 rpm to 25 rpm and by reducing the pitch from 300 mm to 150 mm. It was also necessary to mix thoroughly the contents of the sample prior to hand sub-sampling. This was time consuming and arduous and in practice it would be necessary to increase the number of automatic flip-flap sub-samplers.

Reject material conveyor: The reject material from the sub-sampling station was pneumatically conveyed back to the vehicle via a large blower.

Sample shredder: The cane preparation out of the Hippo mill was still too coarse for analysis (somewhat poorer than the mill prepared cane) and accordingly, was given a further shredding in the sample shredder[1] used for the cane sampled via the full width hatch. After shredding, the cane from the two streams (core and hatch) were indistinguishable in terms of preparation.

Full width hatch sampler and ancilliary equipment.

The full width hatch sampler used in this trial is the standard design sliding gate type used routinely for cane testing operations and is described in the Laboratory Manual for South African Sugar Factories. The two stage sub-sampler and sample shredder are also routinely used standard units as described in the same manual.

Vehicle marshalling system.

A traffic light system was designed and installed to control the marshalling and movement of vehicles at the core station. Vehicle positioning was controlled with the aid of guide rails, road humps and beacons. The driver was made to alight from the cab whilst the corer was being operated (red robot signal).

Laboratory analytical equipment.

All items of laboratory equipment used in the trial were the standard items used routinely in the CTS for direct analysis of cane as described in the Laboratory Manual for South African Sugar Factories.

Procedure

The core sampler was installed at the Darnall sugar mill.

A relatively high proportion of its cane crush is delivered in Hilo vehicles but there are no rail deliveries. The absence of rail deliveries on which to test the corer was not considered a shortcoming as the orientation of the cane bundles within a Hilo is more varied than in a railway truck and if the core sampler can cope satisfactorily with a Hilo then it is reasonable to expect that its operation with the railway truck would also be acceptable. Other factors in favour of conducting the trial at the Darnall mill at that time, were the extended crushing season at this mill (well into February, 1983) which permitted more time for the trial and that extraneous matter measurements, which were needed for the trial, were conducted on a routine basis.

The trial was planned to run round the clock and two persons per 8 hour shift, were employed to attend to the core sampling operations while a few additional items (notably extra ovens for cane moisture determination) were added to the cane testing laboratory. The target was to inspect three or four Hilo loads per hour with the core; these consignments would also be tested via the CTS routine using the hatch sampler. Selection of Hilo vehicles for core testing was essentially random, although the computer was used to monitor the number of tests in each test category (burnt, trashed, variety, load configuration, etc.) so that corrective action could be taken if the number of tests in a particular category were too low. Standard core sampling procedure was to take 3 cores along the central longitudinal axis of the vehicle.

Extraneous matter and ash % cane (soil) tests were conducted by the milling staff in accordance with the procedures prescribed in the Laboratory Manual for South African Sugar Factories.

Precision and bias.

The two desired properties of cane test results obtained by a cane sampling system are that the results should be reasonably precise or repeatable and that they should not be substantially biased relative to the true value.

Of particular importance is that whatever biases exist, they should be consistent or should differ only slightly for different types or categories of cane.

Testing for bias: As a check on the hatch sampler, 100 tests were done to compare the "static" and "dynamic" modes of operation of the hatch. This involved capturing a single hatch fall-out in the routine operating manner (this is the "dynamic" sample). The cane elevator was immediately stopped and the hatch door fully opened and held in this position while a whole slat load of cane was carefully fed into the open aperture so that the entire load was captured ("static" sample). The latter technique is the best means of sampling that could be devised and the results obtained for the static tests were taken as the standard.

The only means for testing the core sample for bias in this investigation was by comparing it with the hatch result. To check the consistency of any bias, deliveries were classified and examined in terms of:

- variety of cane,
- method of infield loading,
- bundle configuration within the Hilo,
- burnt or trashed,
- age of cane at harvest,
- wear/period of use of core cutting head,
- overall time delay (burnt/cut to crush),
- time delay — core sample to hatch sample,
- trash % cane,
- tops % cane, and
- time of day of core sampling.

Testing for precision: With hatch sampling, it is possible to take two samples from a delivery which can be regarded as random and independent. This is because only a small portion of the consignment is not available to the sampler due to the overlap with the adjacent consignments. The method entails collecting alternate hatch fallouts separately and is described by Buchanan and Brokensha.[3]

Such a procedure is impracticable with core sampling under the conditions of this trial because a relatively large portion of the consignment in the Hilo is inaccessible to the corer and to obtain two effectively random and independent samples, it would be necessary to go to the extreme of unloading and reloading the delivery vehicle before taking the second sample.

Sub-sampling efficiency at the corer: Due to the unmixed and therefore stratified nature of the sample material yielded by the corer, it is essential that the sub-sampling procedures be efficiently performed. To ensure that adequate efficiency was being attained, tests were conducted wherein 3 cores were captured and processed via the normal routine i.e. Hippo mill preparation followed by automated sub-sampling with two flip-flaps, hand sub-sampling incorporating thorough mixing, coning-and-quartering, and a final particle size reduction in the sample shredder. Three further cores were captured from the same vehicle (immediately adjacent to the original 3 coring positions). Each of these cores was processed separately through the Jeffco-cutter-grinder (which yields a very finely prepared material) and each of these three portions of Jeffco prepared cane was thoroughly mixed and sub-sampled to a small amount via coning-and-quartering. These 3 end-amounts (one from each core) were then mixed together to form the sample which was analysed for comparison with the routine result.

Core versus hatch test comparisons for individual growers: Ledger accounts were compiled for individual growers, reflecting core versus hatch test comparisons for individual consignments and in respect of weekly and to-date averages.

Grab sampling performance: In the course of this trial it was felt that it would be useful to determine the grab sampler precision and accordingly, a limited number of tests were carried out wherein Hilos were sampled and tested using core versus grab versus hatch comparisons.

Results and Discussion

Precision.

The total number of deliveries tested by the two methods over an 11 week period was 3 058.

The variances of the core and hatch cane test value from all these deliveries, and the derived variances of the sampling errors are shown in Table 1.

TABLE 1

Variance of cane test results and derived sampling error variance

	Variances of test results (3 058 deliveries)			Derived estimates of variance		
	Hatch test	Core test	Core−hatch differences	"TRUE" variation	Hatch sampling error	Core sampling error
Pol % cane	$1,08^2$	$1,48^2$	$1,18^2$	$0,99^2$	$0,43^2$	$1,10^2$
Brix % cane	$0,92^2$	$1,25^2$	$1,03^2$	$0,82^2$	$0,42^2$	$0,94^2$
Moisture % cane	$1,93^2$	$2,51^2$	$2,08^2$	$1,69^2$	$0,93^2$	$1,86^2$
Fibre % cane	$1,95^2$	$2,58^2$	$2,23^2$	$1,65^2$	$1,03^2$	$1,98^2$
Purity	$3,80^2$	$4,76^2$	$3,87^2$	$3,32^2$	$1,83^2$	$3,41^2$
Non-pol	$0,37^2$	$0,58^2$	$0,50^2$	$0,41^2$	$0,29^2$	$0,41^2$
Fibre/pol ratio	$0,25^2$	$0,37^2$	$0,31^2$	$0,23^2$	$0,11^2$	$0,29^2$

Note: Variance = $(S.D.)^2$

It is clear that the variances of core values exceed those of the hatch by a considerable margin for all the cane test parameters. For example, in the case of pol % cane, the core and hatch figures are $1,48^2$ and $1,08^2$ respectively.

The derived estimates of the variance of sampling errors for pol % cane for the core and hatch samples were $1,10^2$ and $0,43^2$, and the estimate of variance of the true values for all deliveries is $0,99^2$ (see Appendix I). Stepping up the number of cores from 3 to 6 improved the precision (0,2 units pol % cane and 0,3 units fibre % cane) but still left it well above the hatch level.

Initial work showed core precision to be much poorer than that shown in Table 1. An intensive campaign of special tests revealed that the sub-sampling system design and operation was not effective with the stratified nature of the core samples. The system was modified as described earlier.

Confirmation that the sub-sampling system was operating efficiently after the modifications, was provided by the procedure described earlier in which two sets of 3 cores were taken adjacent to one another and one set processed via the normal routine i.e. Hippo mill etc. while the second set was processed through the Jeffco cutter-grinder, hand mixed and sub-sampled etc. in the manner described.

The precision found by the special sub-sampling routine (Jeffco cutter-grinder preparation) compared closely with the corresponding estimate obtained with the data yielded via the modified Hippo/flip-flap sub-sampling system.

It is concluded that the level of precision reflected in Table 1 is all that can be expected from the corer taking 3 cores per vehicle. The core samplers' principal limitation is the small amount of cane which it captures. A 3 core sample taken from a 20 ton consignment would be approximately 40 kg whereas the corresponding hatch sample would be 200 kg (8 fallouts at 25 kg per fallout). Furthermore the material sampled by the hatch is well mixed whereas that sampled by the corer is stratified.

Effects of core sampling precision on the accuracy of growers pol % cane: weekly, monthly and seasonal averages

The following table contains the estimated standard errors of a grower's weekly, monthly and seasonal pol % cane averages obtained with hatch and core sampling, calculated at various levels of cane production. These estimates do not take into account the possible effects of differential bias. It simply affords comparison of the effects of the different levels of precision associated with the two different sampling techniques. Core precision is taken at ±1,1 units of pol % cane and the hatch precision at ±0,43 units of pol % cane.

TABLE 2

Impact of core sampling precision on grower's test results

Tons cane per season	Number of consignments per			Week		Month (4 weeks)		Season (40 weeks)	
	Week	Month	Season	SE Hatch	SE Core	SE Hatch	SE Core	SE Hatch	SE Core
8 000	10	40	400	±0,14	±0,35	±0,07	±0,17	±0,02	±0,06
4 000	5	20	200	±0,19	±0,49	±0,10	±0,25	±0,03	±0,08
800	1	4	40	±0,43	±1,10	±0,22	±0,55	±0,07	±0,17

The lesser precision rendered by the core sampler has a negligible effect on seasonal data. However where only a few tests are involved, the average result obtained with the core sampler is subject to significantly more error than that obtained with the hatch.

Grab sampling precision.

Arrangements were made to sample Hilos by three sampling techniques: core, grab and hatch. Sampling precision estimated from the core/grab-hatch differences for 268 Hilo consignments are given in Table 3.

TABLE 3

Precision: core and grab samplers

	Pol % cane	Fibre % cane
Std. dev. of a consignment test: 3 grabs	±0,76	±1,83
Std. dev. of a consignment test: 3 cores	±1,09	±1,98

Space available for the grab sampling tests at Darnall was restricted and the tests were conducted under adverse conditions. Nevertheless the pol precision of the grab method is much improved compared with the corer.

Earlier work at Felixton sugar mill in 1979 (involving 5 500 consignment inspections) produced the following data: standard deviation of a consignment test with grab sampling; pol % cane ±0,54 and fibre % cane ±1,46.

Differential bias.

To determine the extent of non-random sampling error, the (core−hatch) differences were related to the other variables or measurements which were detailed earlier (e.g. variety, method of loading etc.)

A multiple regression analysis was done for the variables pol % cane, fibre % cane, purity and fibre/pol. The R^2 (adjusted) values obtained were:

Pol % cane	0,013
Fibre % cane	0,034
Purity	0,007
Fibre/pol	0,026

The proportion of the variance accounted for by the factors describing the cane (variety, method for loading, etc) is small. Clearly the differences are largely due to random sampling errors (or possibly some other unmeasured factor).

Hatch bias.

In this case the hatch was investigated for bias by carrying out 100 dynamic versus static tests. The results of these tests are shown in Table 4.

TABLE 4

Hatch bias tests

	Pol % cane	Fibre % cane
Mean of static tests	13,43	16,12
Mean of dynamic tests	13,43	16,06
Residual difference	0,00	+ 0,06
Standard error of difference	± 0,03	± 0,09

There was no statistically significant evidence that differences were affected by the level of extraneous matter present or whether the cane was burnt or trashed. These results were taken as confirmation that the hatch is not subject to significant bias.

Core sampling bias.

This assessment is based on the data obtained after the improvements to the crowncutter and to the sub-sampling technique. Comparison between the core and hatch sampling results for 3 207 consignments and on a weekly basis, is shown in Table 5.

TABLE 5

Comparison of core and hatch sampling

Week Number	No. of Samples	Pol % Cane			Fibre % Cane		
		Core	Hatch	Core-Hatch Difference	Core	Hatch	Core-Hatch Difference
34	246	12,24	12,28	−0,04	16,73	16,83	−0,10
35	197	11,37	11,61	−0,24	17,65	17,62	0,03
36	348	12,42	12,48	−0,06	17,33	17,17	0,16
37	164	12,24	12,39	−0,15	17,74	17,44	0,30
38	272	11,69	11,84	−0,15	17,77	17,54	0,23
39	492	12,12	12,28	−0,16	17,46	17,05	0,41
40	214	11,92	11,83	+0,09	16,80	16,83	−0,03
41	418	11,44	11,52	−0,08	17,53	17,09	0,44
42	262	11,60	11,72	−0,12	18,31	17,72	0,59
43	339	11,69	11,82	−0,13	18,08	17,40	0,68
44	255	11,63	11,64	−0,01	17,96	17,46	0,50
Mean	3 207	11,86	11,95	−0,09	17,58	17,26	0,32
Std. error				±0,02			±0,04

Although the pol and fibre differences are statistically significant they are relatively small. The pol difference is fairly consistent from week to week whereas for fibre, the consistency is not quite as good. A classification of the results into burnt and trashed cane (and ignoring consignments with a mixture of burnt and trashed cane) gave results as indicated in Table 6.

TABLE 6

Core bias: burnt and trashed cane differences (core-hatch)

	Pol % cane	Fibre % cane	No. of tests
Burnt cane	−0,02	−0,05	807
Trashed cane	−0,12	+0,47	2 276
Differential bias	−0,10	0,52	
Standard error	±0,05	±0,07	

The bias in pol % cane is relatively small. However, the fibre difference is substantial and statistically significant.

In Table 7 the classification of the core-hatch differences into trash and tops % cane is shown. Tests conducted prior to those reported in Table 6 have also been included in Table 7.

TABLE 7

Core bias - trash and tops % cane differences (core-hatch)

	Pol % cane (Std error)	Fibre % cane (Std error)	No. of tests
Trash % cane			
Less than 5%	−0,04 (±0,03)	+0,25 (±0,05)	1 671
Between 5 & 10%	−0,10 (±0,03)	+0,31 (±0,06)	1 375
Greater than 10%	−0,45 (±0,11)	+0,56 (±0,20)	159
Tops % cane			
Less than 3%	−0,05 (±0,02)	+0,31 (±0,04)	2 416
Between 3 & 6%	−0,20 (±0,04)	+0,25 (±0,08)	730

There is evidence of a differential bias in pol for both trash and tops % cane (see Table 7). A large bias is apparent in pol for trash levels greater than 10%. However, this result is not based on as many tests as for the lower levels of trash.

Further classification in terms of age of cane, harvest-to-crush time delay, infield loading method and Hilo loading method are shown in Appendix 2. In these categories where there is a pol bias, it is negligible. The fibre bias in the two categories age of cane and infield loading method are however, not so easily dismissed.

Within the framework of all the tests conducted on the core for bias assessment, there is statistically significant evidence of differential bias but at magnitudes which are either small or not based on large numbers of tests.

Inspection of pol % cane averages for individual growers as determined by the core and hatch test methods are compared in Appendix 3. It is seen that whilst the majority of growers exhibit differences between their core and hatch pol % cane to-date averages that are relatively small, there are a number who have differences that are rather high.

Operational logistics of core sampling versus hatch sampling.

Under the conditions of this trial the single-barrel corer took six minutes to capture 3 cores from one Hilo consignment. This delay was viewed with concern by the haulier in view of its potential to increase the turn-around time of vehicles in the cane yard. By speeding up the operation of the corer, it was estimated that at best, a single-barrel corer manned by one operator would require at least 4 minutes to capture 3 cores from one Hilo consignment.

It is understood that at Felixton II, the capture of 3 cores from a single SAR consignment would need to be completed within two minutes; outside of this 2 minute interval, the chain of SAR trucks would be moving (or prone to movement). It was estimated that a triple-barrel corer should be able to complete the capture of 3 cores within 2 minutes; the core station may have to be manned by 2 persons. Two triple-barrel corers would be needed for SAR consignments at Felixton: one for each tandem.

Initially, two tandems will be operating at Felixton II, and together will be capable of processing 30 Hilo consignments per hour, thus restricting sampling time to 2 minutes per vehicle. One triple-barrel corer would, theoretically, meet this need.

In time, when 3 tandems are operating, a second core sampling station would be required for road transport, and a third station would be required for SAR consignments.

If hatch sampling is employed at Felixton II, one hatch sampling installation would be needed at each tandem.

Costs: core sampler versus hatch sampler.

At current prices, the cost of a single-barrel corer (installed) is approximately R160 000. It is estimated that a triple-barrel unit would cost in the region of R250 000. The cost of a hatch sampling station is approximately R85 000. The costs of materials needed for the maintenance (and replacements) of hatch sampling equipment, amounts to R10 000 per hatch sampling installation, per annum. The equivalent figures for single-barrel and triple-barrel core sampling installations are estimated at R15 000 and R25 000, respectively.

Mechanical operation of the core sampler.

Occurrence of mechanical failures was minimal over the 20 week test period.

Conclusion

The trial has shown that the degree of imprecision associated with the core sampler is much greater than with the hatch; the relevant data being as follows:

Standard deviation of a test

	Pol % cane	Fibre % cane
Hatch sampler	±0,43	±1,04
Core sampler	±1,10	±1,98

Bearing in mind that this imprecision has to be superimposed onto the real variations in the quality of cane from one consignment to the next (±0,99 units of pol % cane and ±1,65 units fibre % cane) an individual growers' test results would therefore show the following fluctuations around his mean figure:

Standard deviations

	Pol % cane	Fibre % cane
Hatch sampler	±1,07	±1,95
Core sampler	±1,48	±2,58

At the higher imprecision level encountered with the core for a single test, there is the risk that cane analysis may lose credence with growers even though the individuals' seasonal average will not be seriously affected.

The poorer precision with the corer is because of the limited quantity of cane captured during coring; it failed to gain anywhere near as good a representation of the cane within a single consignment as compared with the hatch. It is possible to improve the precision by taking more cores over a wider coverage. However, an increase from three to six cores per vehicle produced only marginal improvement and it is apparent that to gain a meaningful improvement, the additional coring time, engineering effort and costs involved would probably be prohibitive.

In terms of bias assessment, it is concluded that within the framework of the current tests, there is statistically significant evidence of differential bias but at magnitudes which are either small or not based on large numbers of tests. As far as the capital and operating costs are concerned, it has been found that those for the core sampler are higher than the corresponding costs for the full width hatch sampler.

The investigation has verified that, viewed solely from a cane sampling stand point, hatch sampling is unquestionably more efficient, convenient and cheaper than core sampling.

Acknowledgements

The efforts of members of the SASA Experiment Station, Sugar Milling Research Institute and the Cane Testing Service in the practical application of the trial are greatfully acknowledged.

In writing this paper, the author has drawn freely from the reports prepared in the course of the trial by the SASA Cane Sampling Technical Sub-Committee.

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APPENDIX 1

DERIVATION OF SAMPLING VARIANCES

The observed cane test value for a delivery, obtained by a particular sampling method, is postulated to be made up of the following (additive) components:

1. the true content of the delivery;
2. an overall average bias associated with the particular sampling method;
3. a non-random sampling error (NRE) associated with the particular category of cane being tested, and the sampling method employed (differential bias);
4. the random sampling error (RE) associated with the sampling method.

Taking the example of pol % cane, the variance (V) obtained from all 3 058 deliveries tested by both the core and hatch methods are:

$$V_{(hatch)} = V_{TRUE} + V_{NRE(hatch)} + V_{RE(hatch)} = 1{,}08^2$$
$$V_{(core)} = V_{TRUE} + V_{NRE(core)} + V_{RE(core)} = 1{,}48^2$$
$$V_{(core\text{-}hatch)} = (V_{NRE(hatch)} + V_{RE(hatch)}) + (V_{NRE(core)} + V_{RE(core)}) = 1{,}18^2$$

Solving these equations gives

$$V_{NRE(hatch)} + V_{RE(hatch)} = 0{,}43^2$$
$$V_{NRE(core)} + V_{RE(core)} = 1{,}10^2$$
$$V_{TRUE} = 0{,}99^2$$

This means of estimation relies on the assumption that neither method is such that it causes variation to be reduced. (The use of first expressed juice and Java Ratio would perhaps have been such a method).

APPENDIX 2

DIFFERENTIAL BIAS ASSESSMENT

1. Sort by age of cane

Differences (core-hatch)

	Pol % cane	Fibre % cane	No. of tests
13 - 15 months	−0,16	+0,40	984
16 - 18 months	−0,06	+0,08	1 317
Differential bias	0,10	0,32	
Standard error	±0,05	±0,09	

2. Sort by harvest to crush time delay

Differences (core-hatch)

Hours delay	Pol % cane	Fibre % cane	No. of tests
Less than 24 hours	−0,13	+0,24	464
25 - 48 hours	−0,10	+0,22	1 703
49 - 72 hours	−0,09	+0,20	118

3. Sort by infield loading method

Differences (core-hatch)

Loading Method	Pol % cane	Fibre % cane	No. of tests
Category A	−0,03	+0,78	467
Category B	−0,11	+0,07	1 802
Differential bias	0,08	0,71	
Standard error	±0,06	±0,12	

Category A = mechanically loaded by Funkey-Bell into tip trailer.
Category B = hand loaded into bundles then mechanically loaded via side loader into trailers.

4. Sort by Hilo loading pattern

Differences (core-hatch)

Loading pattern	Pol % cane	Fibre % cane	No. of tests
Category A	−0,08	+0,22	712
Category B	−0,11	+0,23	1 639
Differential bias	0,03	0,01	

Category A = all bundles lodged horizontally within the vehicle.
Category B = some bundles angled upwards within the vehicle.

APPENDIX 3

TABLE OF COMPARISONS

Individual grower's to date pol % cane averages hatch versus core (includes only those with 40 or more dual tests)

Grower	Number of consignments inspected	Pol % cane		Difference	Standard error
		Core	Hatch		
1	70	13,06	12,71	+0,35	±0,12
2	73	13,16	12,82	+0,34	±0,14
3	41	12,80	12,60	+0,20	±0,17
4	40	12,27	12,12	+0,15	±0,24
5	110	13,16	13,10	+0,15	±0,10
6	81	12,87	12,75	+0,12	±0,10
7	62	13,04	12,92	+0,12	±0,14
8	308	13,38	13,27	+0,11	±0,06
9	46	13,01	12,97	+0,04	±0,17
10	179	12,73	12,74	−0,01	±0,09
11	128	12,53	12,55	−0,02	±0,10
12	42	12,35	12,39	−0,04	±0,12
13	78	12,53	12,58	−0,05	±0,15
14	46	12,35	12,43	−0,08	±0,16
15	43	11,53	11,61	−0,08	±0,23
16	52	12,80	12,89	−0,09	±0,16
17	109	12,54	12,65	−0,11	±0,11
18	216	12,06	12,20	−0,14	±0,07
19	43	12,58	12,74	−0,16	±0,18
20	41	11,81	11,97	−0,16	±0,28
21	101	12,12	12,29	−0,17	±0,10
22	464	11,86	12,06	−0,20	±0,06
23	41	12,02	12,34	−0,32	±0,21
24	53	12,48	12,92	−0,44	±0,23
25	76	11,96	12,45	−0,49	±0,15
26	84	11,32	11,82	−0,50	±0,14
27	48	11,12	11,73	−0,61	±0,19