TECHNOLOGY & STANDARDS COMMITTEE	**NICE MEETING**
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Chairman: A.G.DE BOOS (Australia)	Report No: CTF 02

TEAM-3 Progress Report (December 2002)

By

A. R. Lindsay, J. W. Marler, and M. A. Jackson

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BRIEFING PAPER

SUMMARY OF FINDINGS

This report provides an update on the progress of the TEAM-3 trial. It shows that processing performance has improved since the late 1980's and that mills are producing tops with Hauteur values, on average, 4.1 mm longer than is predicted by the TEAM-2 general formula. Larger differences occur as the Hauteur increases above 75 mm. In addition, mills are producing tops which have, on average, CV of Hauteur values 1.6% less than predicted by the TEAM-2 formula and Romaine values that are, on average, 1.8% greater than predicted. With regards to core/comb relationships, the mean fibre diameter of the top is, on average, 0.3 μm coarser than the mean fibre diameter of the greasy wool.

A statistical analysis was conducted on 313 consignments that were submitted by 25 mills as part of the TEAM-3 trial. The analysis shows that the effects of Staple Length and Staple Strength on Hauteur are similar for both the TEAM-2 and the TEAM-3 databases. Using the current TEAM-3 data, the inclusion of CV of Diameter and CV of Length in the regression model results in a small improvement in the prediction of Hauteur. However, based on the data available, fibre curvature does not have a determinable influence on the processing prediction of these 313 consignments. In addition, the use of the Mid Break percentage (M) gives a slight prediction improvement over the use of Adjusted Mid Breaks (M*).

COMMERCIAL IMPLICATIONS – CURRENT AND FUTURE

As this is only a Progress Report, no conclusions or recommendations have been provided. Further analyses will be conducted as more data becomes available. However, the level dependencies identified in the TEAM-3 database would indicate that there is potential for an improvement in processing prediction by developing new prediction formulae for Hauteur, CV of Hauteur, and Romaine.

This Report will be presented to the Commercial Technology Forum on Saturday 30th November at 1100.

INTERNATIONAL WOOL TEXTILE ORGANISATION

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SUMMARY

This report provides an update on the progress of the TEAM-3 trial. It shows that processing performance has improved since the late 1980's and that mills are producing tops with Hauteur values, on average, 4.1 mm longer than is predicted by the TEAM-2 general formula. Larger differences occur as the Hauteur increases above 75 mm. In addition, mills are producing tops which have, on average, CV of Hauteur values 1.6% less than predicted by the TEAM-2 formula and Romaine values that are, on average, 1.8% greater than predicted. With regards to core/comb relationships, the mean fibre diameter of the top is, on average, 0.3 μm coarser than the mean fibre diameter of the greasy wool.

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INTRODUCTION

At the Barcelona 2002 meeting of IWTO, a paper was presented to the Raw Wool Group providing a preliminary analysis of the TEAM-3 database (Lindsay *et al*, 2002). The preliminary report, based on processing data from 163 consignments showed that mills were producing commercial tops with Hauteur values, on average, 4.5 mm longer than predicted by the TEAM-2 general formula. Larger differences were evident as the Hauteur increased above 75 mm. In addition, mills were producing tops which had, on average, CV of Hauteur values 2.5% less than predicted by the TEAM-2 formula and Romaine values that were, on average, 2.0% greater than predicted. With regards to core/comb relationships, the mean fibre diameter of the top was, on average, 0.3 μm coarser than the mean fibre diameter of the greasy wool. A statistical analysis of this database showed that the effects of Staple Length and Staple Strength on Hauteur were similar for both the TEAM-2 and the TEAM-3 databases. Based on the 163 consignments, the only term that could be added to the TEAM-2 model to improve the prediction of Hauteur was CV of Staple Length. The new measurements of CV of Diameter and Mean Fibre Curvature did not appear to have a significant impact on the prediction of Hauteur.

Since this preliminary analysis was presented to IWTO, the TEAM-3 database has almost doubled in size. This report presents data on the processing results of 313 commercial consignments that have been submitted as part of this industry project. The report updates the results presented at Barcelona in May 2002.

At the time of writing, a total of 33 mills had signed an agreement to participate in the TEAM-3 trial and a further 6 mills have signalled their intentions to participate. To date, 25 mills have submitted 350 commercial consignments for the TEAM-3 trial. This report provides a snapshot of current processing practice by examining the results of 313 of these consignments. It was not possible to provide a report on the entire database as further analysis of submitted top samples is required before the data can be included into the TEAM-3 database.

Table 1.   TEAM-3 Participating Mills (as at September 2002)

Country	Mills	Country	Mills
Australia	6	Japan	1
China	10	Korea	1
Czech Republic	1	Singapore	1
France	2	Slovak Republic	1
Germany	1	Taiwan	1
India	4	Thailand	1
Italy	2		

CONSIGNMENT DETAILS

Tables 2 and 3 provide a summary of the major raw wool and processing characteristics of the TEAM-2 and TEAM-3 databases (as at September 2002). A number of characteristics were not reported in the TEAM-2 trials and hence no data is available for these components. The TEAM-3 data reported in Table 2 and Table 3 is derived from 313 consignments totalling 69,023 bales. In contrast, the TEAM-2 database totalled 603 consignments.

Table 2.   Range and Mean of the Raw Wool Characteristics of Consignments

	TEAM-1 & TEAM-2 Total Database			TEAM-3 Database (September 2002)		
	Avg	Max	Min	Avg	Max	Min
Schlumberger Yield (%)	--	--	--	70.05	78.05	60.15
JCSY Yield (%)	--	--	--	71.38	79.16	62.43
Vegetable Matter Base (%)	2.1	10.0	0.1	1.1	5.3	0.3
Mean Fibre Diameter (μm)	22.0	31.0	17.0	20.6	24.9	16.5
CV of Diameter (%)	--	--	--	21.5	23.4	19.1
Comfort Factor (%)	--	--	--	96.9	99.5	85.4
Mean Fibre Curvature (deg/mm)	--	--	--	92	124	74
Staple Length (mm)	86	123	59	87	104	71
CV Length (%)	19	30	12	18	25	14
Staple Strength (N/ktex)	39	60	23	39	49	29
Tip Breaks (%)	--	--	--	22	54	6
Mid Breaks (%)	--	--	--	53	77	28
Base Breaks (%)	--	--	--	25	57	6

Table 3.   Range and Mean of the Processing Characteristics of Consignments

	TEAM-1 & TEAM-2 Total Database			TEAM-3 Database (September 2002)		
	Avg	Max	Min	Avg	Max	Min
Hauteur (mm)	67	97	48	73	91	58
CV of Hauteur (%)	49	61	31	46	58	33
Short Fibre % < 25mm	9	20	0	7.0	48.8	0.4
Length > 5%	--	--	--	127	145	106
Romaine (%)	8	21	1	8.5	17.7	2.3
Top & Noil Yield (%)	64	77	46	71.2	79.3	56.9
Mean Fibre Diameter (μm)	22.1	31	17	20.9	25.4	16.6
CV of Diameter (%)	--	--	--	21.0	23.4	17.3
Comfort Factor (%)	--	--	--	96.6	99.7	82.8

## PROCESSING PERFORMANCE AND COMPARISON TO TEAM-2

It has been recognised for some time that mills around the world produce wool tops with significantly longer Hauteur values than those predicted by the TEAM-2 formula. One of the purposes of the TEAM-3 trial is to quantify the magnitude of these differences and to propose any corrections to the existing formulae. The preliminary analysis of the TEAM-3 database based on 163 consignments (Lindsay *et al,* 2002) showed that, on average, mills produced tops with Hauteur values 4.5 mm longer than is predicted by the TEAM-2 formula. Based on the expanded database of 313 commercial consignments, the average difference has dropped slightly to 4.1 mm (Table 4). In terms of CV of Hauteur, the preliminary report showed that actual values were, on average, 2.5% less than predicted. Using the expanded database this has dropped to actual CV of Hauteur values 1.6% less than predicted. The initial report also showed that actual Romaine values were 2.0% greater than predicted and this has dropped slightly to 1.8% in the expanded database.

Table 4.   Comparison between Actual and Predicted Hauteur, CV of Hauteur and Romaine (Derived from 313 processing consignments).

	HAUTEUR (mm)			CV of HAUTEUR (%)			ROMAINE (%)		
	Predicted	Actual	Diff.	Predicted	Actual	Diff.	Predicted	Actual	Diff.
Mean:	68.7	72.8	4.1	47.2	45.6	-1.6	6.6	8.5	1.8
St Dev:	4.4	6.1	3.9	2.9	4.3	3.3	1.2	2.2	1.7

Figures 1-3 show graphically the differences between actual and predicted Hauteur, CV of Hauteur and Romaine. The slopes on these three graphs confirm the notion that processing performance has changed significantly over the past 15 years and strongly suggest that new prediction formulae are required for each of these parameters.

Although the average difference between actual Hauteur and TEAM-2 predicted Hauteur is 4.1 mm, Figure 1 shows that the differences are larger for Hauteur values in excess of 75 mm. The average difference between actual and predicted Hauteur is 6.9 mm for all those consignments with an actual Hauteur of 75 mm or greater. A total of 119 (38%) of the 313 consignments have Hauteur values in excess of 75 mm.

Figure 1: Hauteur Differences

Figure 2: CV Hauteur Differences

Figure 3: Romaine Differences
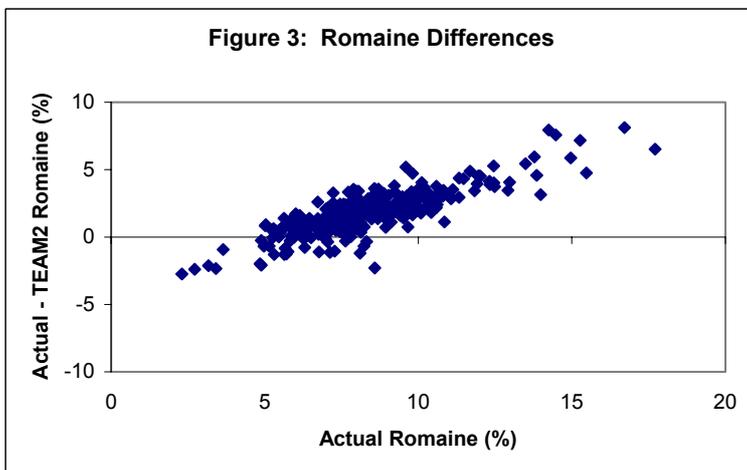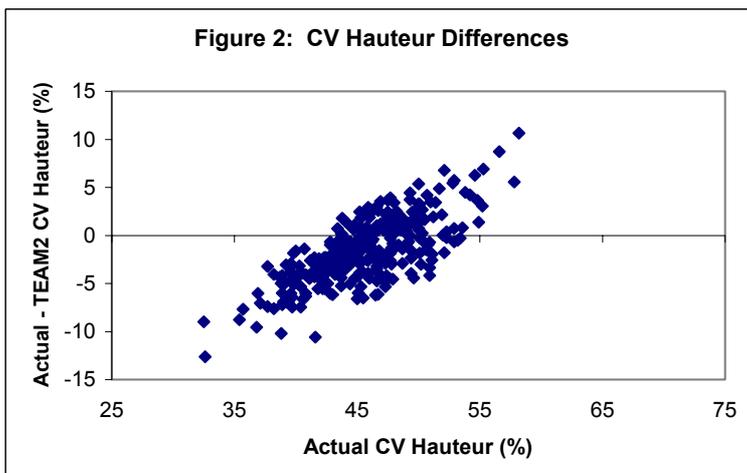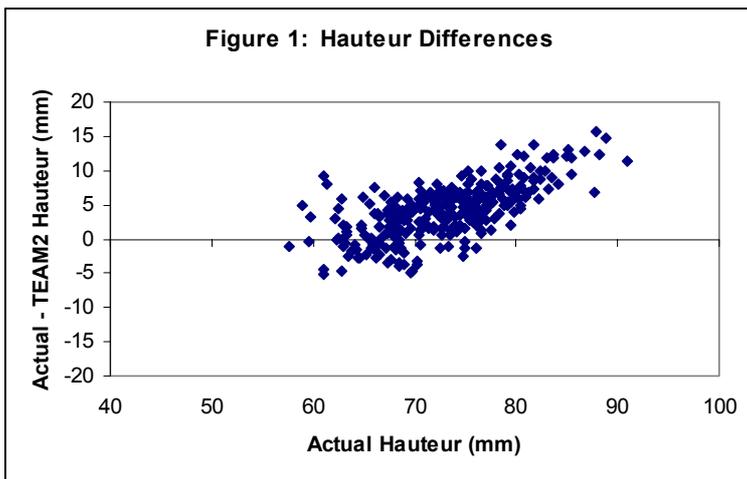
CORE/COMB RELATIONSHIPS

Figure 4 shows the relationship between the core mean fibre diameter and the top mean fibre diameter for the 313 commercial processing consignments. For each processing consignment submitted as part of the TEAM-3 trial, a minimum of five samples of top are provided to AWTA Ltd for analysis. The diameter of the top that is used in this analysis is that measured by AWTA Ltd, using Laserscan. As such, Figure 4 shows a direct comparison between the Laserscan core result and the Laserscan top result. On average, the mean fibre diameter of the top is 0.3 μm coarser than the mean fibre diameter of the greasy wool. This is the same relationship that was reported to the Barcelona meeting of IWTO based on 163 consignments.

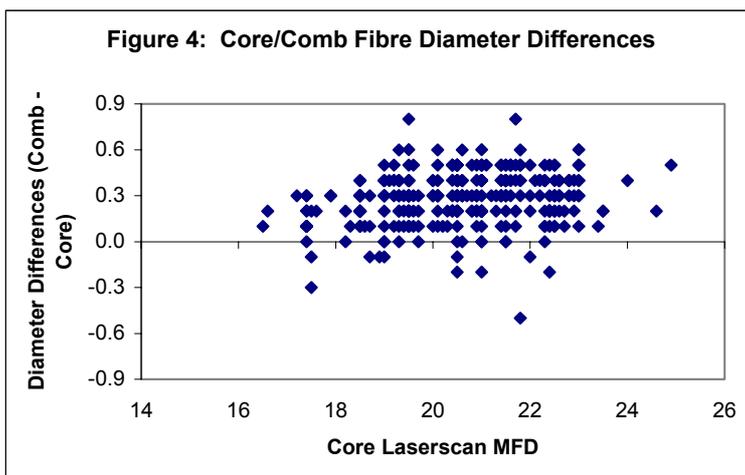Figure 4: Core/Comb Fibre Diameter Differences

Figure 5 compares the CV of Diameter of the greasy wool and the top. It shows that the CV of Diameter is, on average, 0.5% lower in the top than it is in the core. This is an expected result as processing is understood to remove proportionally more fine fibres than coarse fibres as noil. This has the effect of increasing the fibre diameter in the top (Figure 4) and decreasing the fibre diameter variation (CV of Diameter) in the top. As a comparison, the Barcelona report showed that the CV of Diameter was 0.6% lower in the top than it was in the core.

Figure 5: Core/Comb CV of Fibre Diameter Differences
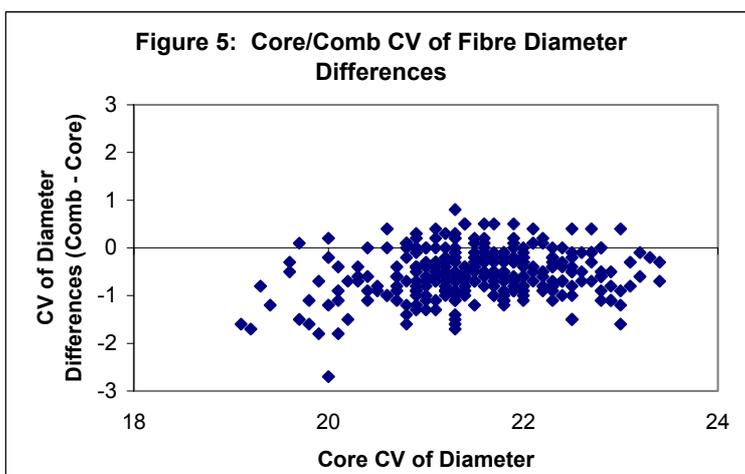
YIELD COMPARISON

Figure 6 shows a comparison between the actual Top and Noil yield achieved by the processing mills and the predicted yield using the Schlumberger Dry Top and Noil Yield (SDRY) formula. It shows that, on average, actual yield is 1.1% higher than the yield predicted by the SDRY formula. The difference reported at Barcelona was 0.9%.

Figure 6: Yield Comparison (Actual & SDRY)
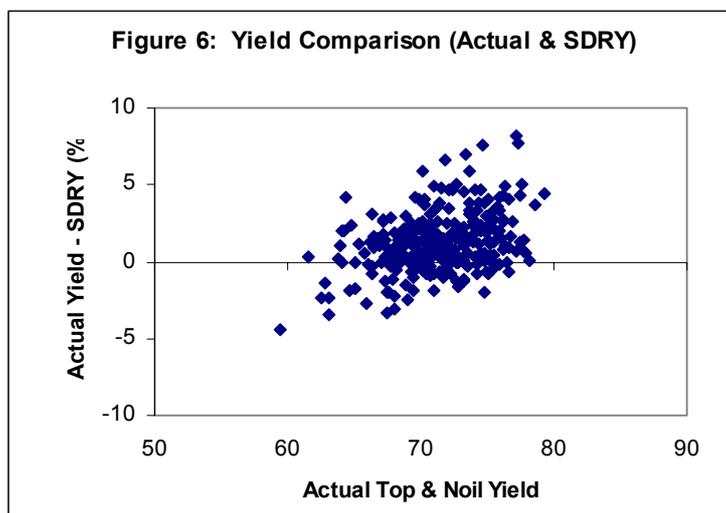
PRELIMINARY STATISTICAL ANALYSIS OF TEAM-3 DATA

The data from the consignments submitted for the TEAM-3 trial was analysed using the S Plus statistical package. As with the preliminary report presented to IWTO in May 2002, the analysis included re-determining the coefficients for the current TEAM formula for Hauteur and then adding either one, two or three new variables to the model. The variables added were Mean Fibre Curvature (MFC), CV of Diameter (CVD), and CV of Length (CVL). Eight different multiple regression analyses were conducted which plotted Hauteur against the factors shown in Table 5.

Table 5.   Variables for Regression Analysis

Regression	Variables Used
1	TEAM (SL, SS, MFD, VMB, M*)
2	TEAM + MFC
3	TEAM + CVD
4	TEAM + CVL
5	TEAM + MFC + CVD
6	TEAM + MFC + CVL
7	TEAM + CVD + CVL
8	TEAM + MFC + CVD + CVL

For reference, the TEAM-2 general equation, as published in 1988, is as follows:

H = 0.52L + 0.47S + 0.95D – 0.19M* - 0.45V – 3.5 + [MA1]

Where: H   = Hauteur (mm)

                 D   = Mean Fibre Diameter (μm)

                 L   = Staple Length (mm)

                 S   = Staple Strength (N/ktex)

                 V   = Vegetable Matter Base (%)

                 M* = Adjusted percentage of middle breaks (for M = 0-45%, M* = 45, for M >46%, M* = M)

                 MA1 = Mill Adjustment Factor (negative or positive)

TEAM-2 VERSUS TEAM-3 COMPARISON

Table 6 is of identical format to the table presented in the Barcelona report. Regression 1 is an analysis of the TEAM-3 database using Staple Length (SL), Staple Strength (SS), Fibre Diameter (D), Adjusted Mid Breaks (M*) and Vegetable Matter Base (V) as a function of Hauteur. These are the same coefficients that formed the basis of the TEAM-2 equation (as shown in bold in Table 6). It is noticeable that the regression analysis on the TEAM-3 database gives a lower Standard Error (SE) than was reported for TEAM-2, suggesting improved repeatability.

Although the coefficients for SS and SL are similar between Regression 1 and TEAM-2, there are some marked differences. Firstly, the effect of Fibre Diameter is more significant in the TEAM-3 analysis (1.50 compared to 0.95). Secondly, the effect of Vegetable Matter Base (V) is markedly different between the two trials. In TEAM-2, VMB had a negative effect of Hauteur (-0.45), as would be expected. However, the TEAM-3 analysis shows that VMB has a positive effect (0.44, although it is not statistically significant), i.e. as VMB increases so too does Hauteur. This is most likely due to the very small range of VMB in the TEAM-3 database (Table 2). The average VMB of the database is 1.2% with a range from 0.4% to 5.3%. However, of the 313 consignments 94% of them have a VMB result of 2.0% or less. This can be clearly seen in Figure 7. With such a narrow range, it would be expected that VMB would have a minimal effect on Hauteur.

## THE ADDITION OF NEW VARIABLES TO THE TEAM MODEL

The remainder of Table 6 shows a summary of the results from the additional regression analyses that were conducted. The report presented to Barcelona showed that the addition of CVD or MFC to the linear regression model did not improve the prediction of Hauteur. Only the addition of CVL improved the model with the Standard Error (SE) decreasing and the R^2 increasing. However, the regression analysis on the increased data set shows that the addition of CVD (Regression 2) and CVL (Regression 4) improve the processing prediction model with the SE and the R^2 improving slightly over Regression 1. It is also worth noting that when CVD is added to the model together with the TEAM-3 variables (Regression 2) that the coefficients for both SS and CVD are significant. There has been some opinion that CVD could replace SS as a predictor of processing performance. This analysis suggests that SS is still important for processing prediction.

Although the use of Fibre Curvature in its own right did not improve the processing prediction model (Regression 3), the regression with the lowest SE (Regression 8) did in fact include Fibre Curvature. This analysis involved predicting Hauteur using the TEAM-2 variables together with CVD, MFC and CVL. This resulted in the lowest SE of 2.68 mm and the equal highest R^2 of 82%.

Table 6.   Statistical Analysis using Additional Factors of CVD, MFC and CVL.

Regression		SL	SS	D	M*	V	CVD	MFC	CVL	SE (mm)	R²
	TEAM-2	0.52	0.47	0.95	- 0.19	- 0.45				3.4	84%
1	TEAM-3	0.46	0.47	1.50	-0.17	*0.44*				2.81	80%
2	TEAM-3 +CVD	0.34	0.26	2.04	-0.19	*0.17*	-1.44			2.74	81%
3	TEAM-3 + MFC	0.46	0.48	1.27	-0.17	*0.48*		*-0.05*		2.81	80%
4	TEAM-3 + CVL	0.34	0.42	1.76	-0.17	0.58			-0.52	2.73	81%
5	TEAM-3 + CVD + MFC	0.33	0.25	1.61	-0.19	*0.23*	-1.61	*-0.10*		2.73	82%
6	TEAM-3 + CVD + CVL	0.26	0.25	2.16	-0.18	*0.34*	-1.19		-0.45	2.69	82%
7	TEAM-3 + MFC + CVL	0.35	0.44	1.47	-0.16	*0.64*		-0.06	-0.53	2.73	82%
8	TEAM-3 + CVD + MFC + CVL	0.25	0.25	1.73	-0.18	*0.40*	-1.36	-0.10	-0.45	2.68	82%

Note: All coefficients that are not statistically significant are in Italics and Bold.

Figure 7: Relationship Between Vegetable Matter and Hauteur
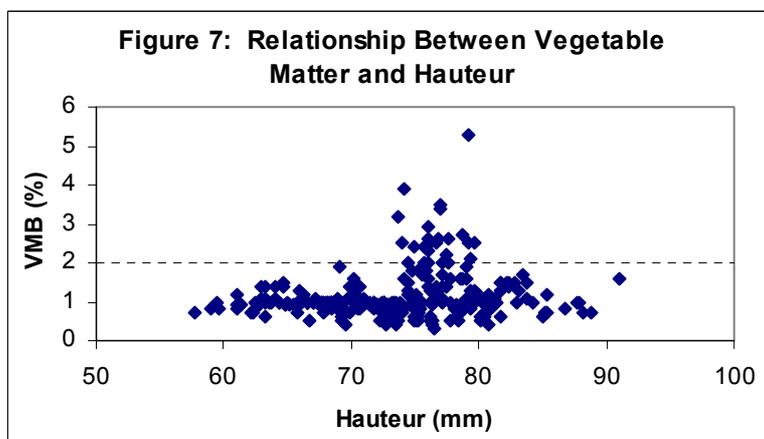
THE USE OF M* IN THE TEAM MODEL

Since the TEAM-2 report was published in 1988, there has been some conjecture over the use of M* (adjusted mid breaks) in the TEAM-2 general equation. M* is the adjusted percentage of middle breaks and all values of M up to 45% are replaced by a value of 45% for M* in the TEAM-2 formula. For values of M greater than 45%, the measured value itself is used as M* in the formula. On the available database of 313 consignments the use of M* was compared to the use of the actual mid break percentage (M). Table 7 shows that the use of M instead of M* resulted in a very small improvement in the SE and R² values of Regression 1 (as reproduced from Table 6). The analysis has shown that despite the effects being very small, the use of M is a possible replacement for M* using the data from the 313 TEAM-3 consignments analysed so far. As the TEAM-3 database continues to expand, further analysis will be conducted comparing the use of M* and M in the prediction models.

Table 7.   Statistical Analysis using M instead of M*.

Regression		SL	SS	D	M*	M	V	CVD	MFC	CVL	SE (mm)	R²
1	TEAM-3	0.46	0.47	1.50	-0.17		*0.44*				2.81	80%
2	M* replaced by M	0.47	0.49	1.48		-0.15	*0.48*				2.80	81%

Note: All coefficients that are not statistically significant are in Italics and Bold.

CONCLUSION

This report has provided an update on the progress of the TEAM-3 trial. It has been shown that processing performance has improved since the late 1980's and that mills are producing tops with Hauteur values, on average, 4.1 mm longer than is predicted using the TEAM-2 general formula. Larger differences occur as the Hauteur increases above 75 mm. In addition, mills are producing tops with CV of Hauteur values, on average, 1.6% less than predicted by TEAM-2 and Romaine values 1.8% greater than predicted. The level dependencies identified in the TEAM-3 database would indicate that there is potential for an improvement in processing prediction.

The core/comb comparison for the data set shows that the diameter of the top is, on average, 0.3 μm coarser than the diameter of the core. In addition, the CV of diameter decreases by 0.5% in the top.

Using the current TEAM-3 data, the inclusion of CV of Diameter and CV of Length in the regression model results in a small improvement in the prediction of Hauteur. However, based on the data available, fibre curvature does not have a determinable influence on the processing prediction of these 313 consignments. In addition, the use of the Mid Break percentage (M) gives a slight prediction improvement over the use of Adjusted Mid Breaks (M*).

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