SUCKERING: A FACET OF IDEOTYPE SELECTION AND DECLINING CCS IN THE WET TROPICS

By

NILS BERDING[1] and A.P. HURNEY[2]
[1]*BSES, Gordonvale, Qld*
[2]*BSES, Tully, Qld*

Abstract

Declining CCS in the northern sugar industry in the past six years largely can be ascribed to dilution of mature-stalk CCS by increased sucker-culm content in the crop resulting from climatic change. This research collected culm composition and quality component data from two trials containing a broad range of clonal variation. Subjective and objective estimates of sucker-culm contribution and full quality component analyses were obtained for mature stalks and sucker culms. There was wide clonal variation for sucker-culm content. Ranges for sucker-culm and mature-stalk component values were discrete for all components except fibre. Genetic variation was restricted more for all mature-stalk components than for most sucker-related measures. Despite subjective and objective sucker-culm estimates being moderately correlated, exploration of net merit grade options using these showed the concept was well applied in practice. Net merit grade was highly predicted by the independent variables used, but a modification proposed adjusts the relative contributions of these to more equitable levels. There is ample genetic variation for propensity to sucker and selection for clones of low suckering propensity will be successful. The proposed net merit grade change equalises the relative contribution of appearance, or ideotype, assessment and CCS difference at about 56% of the level of relative economic value.

Introduction

Skinner (1967) described a grading system for sugarcane clonal assessment that incorporated an 'appearance' component in addition to determination of cane yield and sugar content, as measured by commercial cane sugar (CCS). These characters were not detailed, but in practice include habit, propensity for producing sucker culms, propensity for flowering, and canopy cover. In effect, these were agronomically important, non-yield traits that facilitated production of a high quality crop. Since development, this system has been the basis for clonal assessment in BSES selection programs.

Donald (1968) contended that most crop improvement was based upon 'defect elimination' and 'selection for yield' and he advocated the addition of a third element he called 'the breeding of model plants or ideotypes'. Models are widely used in many technological and scientific fields, and Donald asked why this concept could not be used in crop improvement.

In a sense, Skinner's (1967) appearance concept was a proposal for ideotype selection in that a model plant type was suggested for sugarcane, being erect, with no sucker culms, non-flowering and possessing good canopy cover. While his approach may not have contained the physiological finesse inherent in Donald's (1968) proposal, he sought to emphasise plant traits, or form, that conferred functionality for productivity and quality production.

Ideotype selection is important in sugarcane improvement, but is not well developed relative to other major crops, and little research on this is evident. However, researchers at Cenicaña in Colombia have been active in this area. Amaya *et al.* (1996) investigated a broad range of traits that might predict erectness, and described an ideotype that facilitated selection. Under pressure to move from a burnt to a green harvest regime in a matter of five years, Cassalett *et al.* (1996), at the same institution, described variation available for self-stripping clones that would allow

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development of highly productive cultivars suitable for green harvesting. More recently, Cenicaña have released four cultivars that possess 'short cabbage', and are more resistant to lodging (A. Amaya, pers. comm.).

In the environment of declining CCS in the northern region in the past six years, crop improvement has been criticised for inappropriate outcomes and use of inappropriate selection criteria. Increasing sucker-culm content was considered one factor responsible for declining CCS through dilution of mature-stalk CCS (Leslie and Wilson, 1996). This change in crop composition is associated with climatic change resulting in marked wet episodes during harvest and record or near record crop yields in this period (Berding and Hurney, unpublished). This paper focusses on suckering as a facet of ideotype selection in sugarcane improvement in northern Queensland, and contrasts mature-stalk and sucker-culm quality components. The availability of subjective and objective data for sucker-culm yield allowed exploration of clonal assessment options that resulted in proposed changes to this.

Materials and methods

Final assessment trials (FATs)

The third and final selection stage in the BSES's crop improvement program in the northern region is known as the final assessment trial, or FAT. A second ratoon FAT located on a Clifton soil series on the eastern side of Edmonton was harvested on 20–22 October 1998. The cane in the trial was severely lodged. The trial was of standard format of two replicates of a resolvable, incomplete-block, alpha design. There were 95 plots per replicate. Each plot was four rows, 9.5 m long. Rows two and three of each plot were mechanically harvested and weighed. Prior to this, a sample of six mature stalks was removed from these rows in each plot for full component analysis (Brix, CCS, fibre, moisture, and pol reading). In addition to assigning an appearance grade (AG), the proportion of total culm yield in each plot being contributed by sucker culms (E%Su) was estimated. The AG is allocated relative to the desired ideotype—erect, non-suckering, non-flowering, and with complete cover. This ideotype is scored as 10.0 on a 0–20 scale. Deviations from this result in penalties based on economic impact of the defects. Sucker culms were cut from row four of each plot. Sucker culms are phenotypically distinct and culms >300 mm to the last exposed dewlap were sampled. Loose leaves and all leaf material above the last exposed dewlap were removed. Sucker culms from each plot were weighed to determine the proportion of total plot weight contributed by sucker culms (%Su), and a sub-sample of ≈10 kg was bagged for full component analysis. Analyses reported for mature-stalk and sucker-culm sub-samples were conducted using traditional techniques.

A similar exercise was conducted in 1999 in a second ratoon FAT located north of Gordonvale, on a Virgil series soil. The trial was harvested on 11–13 October and the crop was severely lodged. The design was essentially the same as described above, except row length was 9.6 m. There were 91 plots per replicate. Data collected were as described above, except that the sucker culms in row one were counted prior to being cut and weighed. Analyses reported for mature-stalk and sucker-culm sub-samples were conducted using routine near infra-red spectroscopic analytical techniques (Berding and Brotherton, 1999).

Effect of sucker culms on clonal assessment

The presence of sucker culms in clonal plot assessment has dual effects. Their inclusion in yield assessment has a positive effect in that yield is biased upwards. Inclusion of sucker culms in quality component assessment, by either use of billet samples or arithmetically weighted analyses, has a negative effect on CCS values obtained from analyses of mature-stalks. Consideration of these effects yields the four scenarios depicted, + +, − +, + −, and − − (Table 1). Use of total culm yield (mature stalks and sucker culms, T(C+Su)H) and mature stalk CCS, for example, equates to the + + scenario.

The net merit grade (NMG) statistic used in BSES clonal assessment (Skinner, 1967) summarises the value of a clone to the industry. The NMG is computed as:

NMG = (RSY + 0.003*CCS diff.)*AAG − 0.013*(fibre diff.),

where

AAG = AG of a clone, adjusted relative to the standard cultivars in the trial receiving a mean of 10.0.

CCS diff. = difference between a clonal CCS value (g/kg) and the mean CCS of the standard cultivars in the trial.

Fibre diff. = difference between a clonal fibre value (g/kg) and the mean fibre of the standard cultivars in the trial.

RSY = sugar yield of a clone (t/ha) expressed relative to the mean sugar yield of the standard cultivars in the trial.

Table 1—Effect of sucker culm inclusion on yield and quality components in small-plot clonal assessment, and net merit grade (NMG) options explored via adjustment of appearance grade (AG) by use of either a subjective estimate of sucker-culm content of total plot culm yield (E%Su) or an objectively determined estimate of this component (%Su).

Effect of sucker culms on		NMG options	
Cane yield[1]	CCS[2]	Via E%Su	Via %Su
T(C + Su)H +	$CCS_{(ms)}$ +	AG = NMG1	–
TCH –	$CCS_{(ms)}$ +	AG + E%Su/10 = NMG2	AG + %Su/10 = NMG2M
T(C + Su)H +	$CCS_{(w)}$ –	AG + E%Su/10 = NMG3	AG + %Su/10 = NMG3M
TCH –	$CCS_{(w)}$ –	AG + E%Su/5 = NMG4	AG + %Su/5 = NMG4M

[1] T(C + Su)H = tonnes mature stalks + sucker culms per ha; TCH = tonnes mature stalks per ha.
[2] $CCS_{(ms)}$ = CCS of mature stalks; $CCS_{(w)}$ = weighted CCS, on a plot basis, = ($CCS_{(ms)}$ × TCH + $CCS_{(Su)}$ × TSuH)/T(C + Su)H, where $CCS_{(Su)}$ = sucker culm CCS and TSuH = tonnes sucker culms per ha.

In the current situation in north Queensland, assessment and penalty of the propensity to produce sucker culms has been the aspect of the AG that has received most scrutiny. Currently, each 10% of a plot's culm yield produced by sucker culms, assessed subjectively (E%Su), results in a two-point penalty via the AG. One point is deducted for inflation in yield and one point for the over estimate of CCS by one unit by using mature-stalk sub-samples. The CCS penalty has been determined from extensive sampling over recent seasons (Berding and Hurney, unpublished). The data collected allowed exploration of a number of NMG options using either subjective (E%Su) or objective (%Su) sucker-culm yield assessment. If assessment and penalty via E%Su were wayward substitution of %Su for E%Su in the AG would result in divergent NMGs. Table 1 details three such contrasts. The standard NMG defined above, named NMG1 here, is the + + scenario (Table 1). When sucker-culm yield is removed from plot yield assessment, and mature-stalk CCS is still used (the – + scenario), the AG can be adjusted upwards. Use of either half the estimated sucker yield (E%Su/10) or half the objective sucker yield (%Su/10) allows the AG to be discounted for 50% of the effect of sucker culms, and calculation of NMG2 and NMG2M, respectively. Similarly, in the reverse situation (+ –, Table 1) the same adjustments allow calculation of NMG3 and NMG3M. Both effects of sucker culms (the – – scenario, Table 1) can be considered using the subjectively (E%Su/5) and objectively (%Su/5) determined sucker-culm contributions, giving NMG4 and NMG4M, respectively.

Two additional NMG options are examined. Adjustment to the weighting given the CCS bonus in the standard NMG1 from 0.003 to 0.01, a simply applied incentive for high CCS, yields NMG1M. Finally, NMG' arises from use of an estimate of clonal economic value and fully objective sucker-culm yield and component data, as for NMG4M, to penalise the effects of sucker culms on clonal assessment.

NMG' = (REV + 0.01*CCS diff.)*A(AG+%Su/5) – 0.013*(fibre diff.),

where

REV = economic value (EV) of a clone expressed relative to the mean economic value of the standard cultivars in the trial.

EV = (300*TCH*CCS/1000) – 6.5*TCH.
= TCH*(0.3*CCS – 6.5).

The CCS is expressed as g/kg, and the 300 and 6.5 are the price of sugar per tonne and the cost of harvesting per tonne of cane, in AUD, respectively. Obviously, use of REV cannot be construed as a whole of industry perspective, because of the lack of transport and milling costs, and must be considered a partial solution only. In this approach, high tonnage production is penalised via a harvesting-cost penalty, and the CCS differential, in g/kg, is receiving three times the bonus (0.01 vs 0.003) currently assigned.

Statistical analyses

Routine analyses of variance, correlation, and simple and multiple linear regression techniques were used. Estimates of degree of genetic determination (g^2), or broad sense heritability, and genetic coefficient of variation (G.C.V.%) also were computed. In an analysis of variance of a randomised complete block design, the expectation of mean squares for the main effect of clones is $\sigma_E^2 + r\sigma_C^2$, where σ_E^2 = plot to plot error,

σ_C^2 = variance among clones, and r = number of replicates (Burton and de Vane, 1953). On a replicated plot basis, $g^2 = \sigma_C^2 / (\sigma_C^2 + \sigma_E^2 / r)$ and $G.C.V.\% = 100.\sqrt{\sigma_C^2} / \bar{x}$.

Results and discussion

Final assessment trials (FATs)

All clonal terms in the analyses of variance of the six harvest traits considered in the 1998 FAT were significant (Table 2). The average crop yield (mature stalks + sucker culms) was high, at 114 T(C+Su)H, with sucker-culm yield ranging from 0.7 to 31.2 TSuH. Genetic coefficient of variation values were largest for any of the measures associated with sucker culms (TSuH, %Su, and E%Su), indicating manipulation of this trait via selection would be successful. The C.V.% values for these were higher than any other yield traits (Table 2). This has practical implications for any future screening procedure for suckering propensity. Estimates of g^2 were moderate to high, with TSuH having the highest value (Table 2). This statistic must be interpreted cautiously as the data are from a single-site clonal trial.

Data for the eight yield components from the 1999 FAT (Table 3) generally reinforced the discussion for the 1998 FAT. There were significant clonal effects for all traits. The average crop yield was lower, at 90 T(C+Su)H, with TSuH ranging from 0.7 to 43.8. The TSuH at this site was 120% of that in the 1998 FAT, yet T(C+Su)H was 79% of the 1998 site. This may be either an environmental effect, i.e., suckering propensity on the Virgil soil is stimulated, or temporal variation. The G.C.V.% values again were excellent for all sucker culm related measures. The g^2 values were also good, but the statistical robustness of these estimates may be suspect without use of data from multiple trials within a year. However, if these trials are considered as 'managed environments', through deliberate choice, these estimates may be realistic, regardless of their robustness, if screening was to be conducted under similar conditions.

Quality component data for mature stalk and sucker culms for the 1998 and 1999 FATs showed clonal effects were significant or highly significant for all traits (Tables 4 and 5). In all analyses, C.V.% values, were low, and the component ranges were wide, spanning many times the relevant least significant difference value. The means for all components of the sucker culms except moisture, were lower than the means for mature stalks. For all components except fibre, the ranges of variation for sucker culms and mature stalks did not overlap. Mature-stalk CCS in 1999 (166.9 g/kg) was 15% higher than in 1998, while sucker-culm CCS (85.6 g/kg) was 308% greater. This highlights the importance of annual environmental variation on differential expression of quality component values in crop components.

The G.C.V.% values for mature-stalk components generally were low, but restricted genetic variation for many quality components is an acknowledged fact. The G.C.V.% values for sucker-culm components were higher, in some cases markedly so. There were marked differentials between values for mature stalks and sucker culms between years, e.g., CCS and moisture. The variation in contrast between the two data sets for mature-stalk vs sucker-culm values is not

Table 2—Mean squares and summary statistics[1] from analyses of variance of traits[2] assessed in a second ratoon final assessment trial harvested in 1998.

		T(C+Su)H	TCH	TSuH	% Su	AG	E%Su
Mean square	Replicates	5451.6**	4464.0**	49.3	0.0	2.8	0.1
	Clones	720.7**	753.0**	96.0**	77.1**	1.8**	90.6**
	Error	305.4	322.2	22.3	23.3	0.8	53.6
Statistic	C.V.(%)	15.3	17.5	41.6	47.1	12.0	60.6
	Mean	114.1	102.8	11.4	10.2	7.5	12.1
	Minimum	79.0	59.3	0.7	0.5	5.5	0.0
	Maximum	182.8	175.8	31.2	25.1	10.0	30.0
	$Lsd_{(0.05)}$	34.7	35.6	9.4	9.6	1.8	14.5
	G.C.V.(%)	12.6	14.3	53.5	50.6	9.4	35.6
	g^2	0.576	0.572	0.767	0.698	0.549	0.408

[1] G.C.V.(%) and g^2 are defined in the Materials and Methods.
[2] T(C+Su)H = tonnes of mature stalks and sucker culms per ha; TCH = tonnes mature stalks per ha; TSuH = tonnes sucker culms per ha; %Su = 100 * TSuH/T(C+Su)H; AG = appearance grade; E%Su = visual estimate of total plot biomass contributed by sucker culms.
*,** P ≤ 0.05 and 0.01, respectively.

Table 3—Mean squares and summary statistics[1] from analyses of variance of yield traits[2] assessed in a second ratoon final assessment trial harvested in 1999.

		T(C+Su)H	TCH	TSuH	% Su	AG	No. sucker culms/ha	kg/100 sucker culms	E%Su
Mean square	Replicates	179.1	679.5*	160.9*	204.8*	1.6	261150691.	751.2*	2.2
	Clones	828.4**	561.0**	130.0**	98.0**	2.9**	346097072.**	531.5**	79.2**
	Error	175.5	166.0	26.6	29.8	1.2	74850214.	134.0	23.6
Statistic	C.V.(%)	14.7	16.8	37.7	36.8	20.0	35.3	21.3	30.9
	Mean	90.4	76.7	13.7	14.9	5.6	24495.	54.3	15.7
	Minimum	38.4	33.7	0.7	0.9	2.5	2431.	26.5	2.5
	Maximum	149.0	125.0	43.8	33.4	9.0	72569.	101.8	35.0
	$Lsd_{(0.05)}$	26.3	25.6	10.2	10.8	2.2	17247.	23.1	9.6
	G.C.V.(%)	20.0	18.3	52.5	39.3	16.2	47.6	25.9	33.6
	g^2	0.788	0.704	0.795	0.696	0.567	0.785	0.748	0.702

[1] G.C.V.(%) and g^2 are defined in the Materials and Methods.
[2] T(C+Su)H = tonnes of mature stalks and sucker culms per ha; TCH = tonnes mature stalks per ha; TSuH = tonnes sucker culms per ha; %Su = 100 * TSuH/T(C+Su)H; AG = appearance grade; E%Su = visual estimate of total plot biomass contributed by sucker culms.
*,** $P \leq 0.05$ and 0.01, respectively.

Table 4—Mean squares and summary statistics[1] from analyses of variance of quality components of mature stalks and sucker culms from a second ratoon final assessment trial harvested in 1998.

Crop component			Brix (g/kg)	CCS (g/kg)	Fibre (g/kg)	Moisture (g/kg)	Pol reading (°Z)
Mature stalks	Mean square	Replicates	937.7**	1436.1**	1034.8**	9.6	248.3**
		Clones	158.9**	129.4*	348.9**	381.5**	37.3**
		Error	72.8	84.6	67.3	109.0	20.2
	Statistic	C.V.(%)	4.2	6.4	5.9	1.5	5.7
		Mean	203.1	144.8	138.7	690.8	78.4
		Minimum	169.7	112.9	111.9	658.8	61.5
		Maximum	219.5	160.6	170.6	723.1	86.3
		$Lsd_{(0.05)}$	16.9	18.3	16.3	20.7	8.9
		G.C.V.(%)	3.2	3.3	8.6	1.7	3.7
		g^2	0.542	0.346	0.807	0.714	0.458
Sucker culms	Mean square	Replicates	106.1	258.0	24.8	87.1	46.7
		Clones	409.4**	480.0**	136.5**	628.6**	93.4**
		Error	99.4	134.7	44.8	176.6	24.9
	Statistic	C.V.(%)	12.0	55.3	6.9	1.6	27.9
		Mean	83.1	21.0	97.2	830.6	17.9
		Minimum	52.8	–7.8	82.4	759.8	5.7
		Maximum	136.5	74.0	126.4	857.1	42.8
		$Lsd_{(0.05)}$	19.8	23.1	13.3	26.4	9.9
		G.C.V.(%)	15.0	62.6	7.0	18.0	32.7
		g^2	0.757	0.719	0.672	0.719	0.734

[1] G.C.V.(%) and g^2 are defined in the Materials and Methods section.
*,** $P \leq 0.05$ and 0.01, respectively.

Table 5—Mean squares and summary statistics[1] from analyses of variance of quality components of mature stalks and sucker culms from a second ratoon final assessment trial harvested in 1999.

Crop component			Brix (g/kg)	CCS (g/kg)	Fibre (g/kg)	Moisture (g/kg)	Pol reading (°Z)
Mature stalks	Mean square	Replicates	137.1	87.7	68.9	230.7	37.0
		Clones	123.9**	136.9**	219.3**	236.6**	33.7**
		Error	47.3	78.0	46.2	65.9	16.5
	Statistic	C.V.(%)	3.0	5.3	4.9	1.2	4.5
		Mean	231.8	166.9	139.5	667.6	90.8
		Minimum	211.5	147.0	115.0	638.8	80.3
		Maximum	247.5	182.8	165.5	696.9	99.0
		$Lsd_{(0.05)}$	13.7	17.5	13.5	16.1	8.1
		G.C.V.(%)	2.7	3.3	6.7	13.7	3.2
		g^2	0.618	0.430	0.789	0.722	0.509
Sucker culms	Mean square	Replicates	148.3	471.0	6.6	114.1	90.5
		Clones	800.7**	913.1**	164.8**	972.9**	194.7**
		Error	288.8	342.3	66.6	388.3	72.3
	Statistic	C.V.(%)	12.3	21.6	7.2	2.5	17.4
		Mean	137.8	85.7	114.1	780.0	48.8
		Minimum	81.3	29.1	92.7	737.6	21.6
		Maximum	175.3	129.4	133.9	845.1	67.5
		$Lsd_{(0.05)}$	33.8	36.8	16.2	39.2	16.9
		G.C.V.(%)	11.6	19.7	6,1	2.2	16.0
		g^2	0.639	0.625	0.596	0.601	0.629

[1] G.C.V.(%) and g^2 are defined in the Materials and Methods section.
*,** $P \leq 0.05$ and 0.01, respectively.

unexpected, but is of little practical interest. The objective of ideotype selection is to seek clones with low suckering propensity, not clones with sucker culms of high CCS. The g^2 values are variable, with values for sucker culms for Brix, CCS and pol reading being higher than mature-stalk values, lower for fibre, and comparable for moisture. Overall, values range from moderate (0.346) to high (0.789).

Effect of sucker culms on clonal assessment

Regression analysis of the %Su in a plot (X) and the reduction in plot CCS resulting from the inclusion of sucker culms in quality component determination (Y = weighted CCS – mature-stalk CCS) yielded the following relationships:

1998 FAT: $\hat{Y} = -1.182X$

1999 FAT: $\hat{Y} = -0.722X$

In the 1998 FAT, inclusion of 10% sucker culms in a plot reduced CCS by 11.82 g/kg, on average, while for the 1999 FAT the average reduction was 7.22 g/kg of CCS. These values compare with the 1.0 AG CCS penalty that currently is allocated for each 10% of sucker culms present in a plot. They agree with the value of 10.6 g/kg obtained by Hurney and Berding (these Proceedings) from objective data from a multi-environment assessment of nitrogen × cultivar interactions.

Exploration of various NMG options was necessary, as criticism has been leveled at BSES selection procedures, in particular the characters being assessed via the AG and their impact on NMG. The relationship between E%Su and %Su, resulting from the estimation of mature-stalk vs sucker-culm contribution to total culm yield, was weak, with r = 0.469 and 0.577, respectively, for the 1998 and 1999 FATs. This is not surprising given the difficulty of assessing E%Su. The adjustment of AG with either E%Su or %Su, as done in the contrasts NMG2 vs NMG2M, NMG3 vs NMG3M, and NMG4 vs NMG4M (Table 1), resulted in high correlations (r = 0.88 to 0.96). The relationship between NMG4M and NMG1 was excellent (0.91 and 0.98). Both NMG1M and NMG' were highly correlated with NMG1 (0.92–0.98). The concept of ideotype selection via the AG, and application of this via the NMG, is being executed well in practice. Substitution of objective for subjective data for sucker-culm composition failed to reveal serious weaknesses in the NMG concept.

While the NMG concept appears robust and effective in practice, examination of the contribution of the independent variables to NMG (Table 6) is essential. Results of multiple linear regression analyses for NMG1, NMG1M, NMG4M, and NMG' are presented in Table 6. All NMGs were highly predicted by the independent variables used (R >0.98). However, not all variables made a significant contribution to the prediction of NMG; e.g., the CCS difference in NMG1, NMG1M, and NMG4M, for both FATs. Disturbingly, the CCS difference had a negative coefficient for NMG1 and NMG1M for the 1998 FAT, the opposite of what is intended. The contribution of fibre difference was significant, small, and negative for all NMG options, and so operates as intended.

The relative importance of the contributions of the independent variables to the NMGs was examined using standard partial regression coefficients (b', Table 6). In NMG1, AG dominated the contribution of variables other than RSY. Increasing the CCS bonus from 0.003 to 0.01 (NMG1M), or using the fully objective measure of the effect of sucker culms on clonal evaluation (NMG4M) resulted in small to moderate reductions in the relative contribution of AG. Substitution of REV for RSY (NMG') dramatically increased the significance and magnitude of the contribution of the CCS difference to NMG (Table 6). The relative contributions of AG to NMG' were lower than to NMG1, but the relativities of AG to CCS difference were approximately equal, with their average importance relative to REV being about 56%. This approach gives CCS difference more weight in NMG', which was not achieved with NMG1, as well as moderating the contribution of AG. In the data sets considered, this did not impact significantly on the selection of clones of high performance, these being selected by NMG1 and NMG'. However, for clones of intermediate performance, NMG' values were lower than those of NMG1, and selection outcomes would differ.

This proposed alteration to the NMG formula is considered robust although the development was based on two data sets. These came from populations of clones that encompassed a broad range of variation for yield (Tables 2 and 3) and quality components (Tables 4 and 5). In particular, the trials had a high level of expression for propensity to sucker. However, the analyses revealed that there was a wide range of variation for this trait, and that this was genetically determined to a high degree. This approach ensures a degree of robustness that cannot be achieved by use of artificial and/or small data sets.

Development of NMG' was based on objective sucker-culm data. However, such data

Table 6—Summary statistics from multiple linear regression studies of four independent variables[1] as predictors for four variations of net merit grade (NMG[2]) using data from second ratoon final assessment trials harvested in 1998 and 1999.

Independent variables	NMG1			NMG1M			NMG4M			NMG'		
		b'			b'			b'			b'	
	t	abs.[3]	rel.[3]	t	abs.	rel.	t	abs.	rel.	t	abs.	rel.
1998 (n = 190)	R = 0.993			R = 0.993			R = 0.982			R = 0.981		
AAG	58.0**	0.521	65	55.4**	0.479	58	34.6**	0.538	50	25.1**	0.400	52
CCS diff.	–1.9	–0.020	–2	–1.4	–0.016	–2	1.8	0.035	3	21.5**	0.417	55
Fibre diff.	–8.0**	–0.072	–9	–8.0**	–0.070	–9	–3.6**	–0.053	–5	–2.8**	–0.043	–6
RSY/REV	76.4**	0.801	100	71.9**	0.822	100	50.1**	1.071	100	37.4**	0.764	100
1999 (n = 182)	R = 0.977			R = 0.977			R = 0.983			R = 0.980		
AAG	46.1**	0.768	103	41.4**	0.698	91	44.4**	0.658	67	35.9**	0.571	69
CCS diff.	0.6	0.011	1	1.0	0.021	3	1.0	0.016	2	24.9**	0.400	48
Fibre diff.	–3.0**	–0.050	–7	–2.6**	–0.045	–6	–3.7**	–0.052	–5	–2.8**	–0.043	–5
RSY/REV	42.7**	0.749	100	38.3**	0.766	100	60.1**	0.986	100	50.1**	0.832	100

[1] AAG = adjusted appearance grade; RSY = relative sugar yield: REV = relative economic value; All independent variables are defined in the Materials and Methods.
[2] NMG options are defined in the materials and methods section.

cannot be acquired routinely from all FATs conducted in the region because of resource restraints. The robustness of the NMG concept was shown earlier. The formula for NMG' simply can be applied by use of the traditionally acquired, subjective AG in place of the AG + %Su/5 used in its development.

The acquisition of E%Su can be improved. Currently, this involves a dual process. The operator estimates T(C+Su)H, and then estimates the percentage of this produced by sucker culms, or E%Su. In fact, T(C+Su)H already is measured objectively, so direct estimation of TSuH would be simpler and more accurate. The estimation must be simple, and allow assessment of a plot quickly, say within 30 s. We propose that personnel assessing trials use a simple 3 × 3 sucker-culm number vs size assessment matrix, to estimate TSuH, as follows:

Sucker-culm number (per 10 m)	Sucker-culm size (mm to LED)		
	Small (< 300)	Medium (≈1000)	Large (>1700)
Few (10)	2	12	22
Some (60)	12	22	34
Many (110)	22	34	44

While this is based on data presented here (Tables 2 and 3), the concept may require experimental verification, and perhaps optimisation.

Conclusions

Ideotype selection, as practiced by BSES personnel in clonal assessment programs, is being well executed via the input of AG to the NMG concept. This will be improved by introduction of the NMG' formula that promises better balance among the variables used to calculate NMG. In addition, a method to allow more accurate estimation of E%Su has been proposed and will be evaluated. Penalties for sucker-culm content were upgraded in the 1998 season, which have been validated by results presented here. Penalties for other major ideotype traits, particularly habit and flowering propensity are soundly based, are acceptable, and are being well implemented. Truncation selection for suckering propensity and unacceptable habit are being implemented more stringently in selection stages 1 and 2 in the northern improvement program. Additional research is in progress to develop selection strategies for erectness and to better understand stimuli influencing sucker-culm initiation. Finally, the increased distancing of selectors from the crop that has occurred because of increased mechanisation has been reversed. Trained selectors will conduct several pre-harvest inspections of plant and first-ratoon FATs that will focus specifically on facets of ideotype of greatest significance in the far north–habit and suckering propensity. These data will compliment current harvest evaluation data for more comprehensive clonal assessment.

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