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COMPARING VARIETY TRIAL AND COMMERCIAL DATA: TRENDS AND RELATIONSHIPS FOR PRACTICAL USE IN THE SOUTH AFRICAN SUGARCANE INDUSTRY

RAMBURAN S

South African Sugarcane Research Institute, Private Bag X02, Mount Edgecombe, 4300, South Africa
sanesh.ramburan@sugar.org.za

Abstract

The Variety Evaluation Project at SASRI involves conducting variety trials throughout the South African sugar industry. A general trend is that trial yields consistently exaggerate commercial yields obtained by growers under the same conditions. The objective of this study was to use historic variety trial and commercial yield data to evaluate the possibility of using correction factors and plot yield estimates to obtain more realistic and better estimates of commercial performance. Additionally, trial data were used to investigate the possibility of using destructive sampling to estimate trial plot yields.

Trial yields consistently followed the same trends as commercial yields since initiation of the project. However, trial yields were on average 30 t/ha more than commercial yields. A correction factor of 0.7 was identified as being appropriate for adjusting trial yields to those of average commercial levels across the sugarcane industry. A suitable correction factor was subsequently calculated for each mill area in the industry (these ranged from 0.54 to 0.9). Off-station trial yields were more consistent with commercial trends than on-station trials. A significant exponential relationship (r^2=0.7) was found between actual plot yields and estimated yields from destructive sampling. Applying a correction factor to estimated yields adjusted the data to correspond with commercial levels. This indicated that destructive sampling, followed by the application of a correction factor, may be an acceptable way of determining realistic trial yields when actual harvesting of trials cannot be done. These results will assist in optimising recommendations derived from the Variety Evaluation Project.

Keywords: sugarcane, estimated yields, commercial yields, trial yields, variety evaluation

Introduction

Post-release variety evaluation trials are conducted by the South African Sugarcane Research Institute (SASRI) throughout the sugar industry as an on-going activity (Redshaw, 1999). The results from these trials are used to predict the likely performance of varieties under comparable commercial conditions. Recommendations to growers are primarily based on variety yield performance and subsequent variety rankings under specified production conditions.

Although aimed at predicting likely variety performance commercially, post-release variety trials often overestimate commercial performance under the same conditions (Bissessur *et al.*, 2007). As a result, these exaggerated trial yields conveyed to growers at information days, grower days, and in popular publications, may be perceived by growers to be unrealistic or unattainable. The unusually high yields may often affect the mindset of the grower, imparting doubt and uncertainty. Consequently, grower confidence in trial results may be lost, leading to ‘questioning’ of results, with subsequent disregard and even non-adoption of variety recommendations. Additionally, exaggerated trial yields could create unfulfilled expectations with regard to variety performance and yields of newly released varieties. A strategy for overcoming this would be to express trial yield results as percentages rather than tons per hectare. This may be effective in some cases; however, the majority of growers place much emphasis on actual trial yields, and use these results as a basis for comparison with their own productivity figures. Trial yields should therefore be expressed on a more realistic basis, so that growers will be able to identify with the results and compare variety performances more accurately.

There have been numerous reports that trial yields overestimate commercial production (Walker and Simmonds, 1981; Bissessur *et al*., 2007). One method of comparing trial and commercial yields would be to establish trials within commercial fields and compare average plot yields from trials to the yields obtained from the commercial fields surrounding the trials (Bissessur *et al*., 2007). However, the difficulty in obtaining accurate commercial data, the limitations on land availability, the practical considerations when working with a large number of trials, and the confounding effect of other factors (e.g. spatial variability and management practices) make this method difficult. Another option is to make use of historic variety trial and commercial data (Mordocco *et al*., 2007), averaged over the industry, to identify broad trends. The identification of such trends and relationships may assist in improving the accuracy of information transfer to the industry.

The overestimation of commercial yields by trials may be a result of reduced variability within the smaller plots (Milligan *et al*., 2007), differences in the methodology of harvesting, or better crop management in the trials. It can be argued whether destructive sampling from trials could serve as a reliable way of predicting yields. With the increasing threat of labour shortages in the South African sugar industry, the validity of using destructive sampling to determine trial yields should be assessed carefully. It is also possible that the 'estimated' trial yields may correspond more accurately to commercial yields than 'actual' trial yields determined from plot weights.

The objective of this study was firstly to compare historic variety trial and industry yield data to determine whether trial data gives a fairly good estimation of commercial yields, and to investigate the possibility of adjusting trial yields to obtain more realistic prediction of actual commercial performance. Secondly, the study aimed at determining the accuracy with which actual trial yields could be estimated from destructive sampling methodologies, and at investigating the possibility of using such estimates rather than actual plot weights to formulate variety recommendations.

Data analysis

Data used in this study were extracted from the Agronomy Database (Bezuidenhout, 1998) as well as from the Industry Information Database (data gathered from growers and millers) at SASRI. Trial yield was determined as an average derived from all post-release variety trials (not plant breeding trials) harvested in a particular year throughout the industry. Commercial yields were calculated as an average of yields obtained from the industry in the same year. The average trial yields were compared to commercial yields over a period of 28 years (1979 to 2006) and the average difference between the two datasets was calculated. The two datasets were also used to calculate a correction factor using equation 1:

$$\text{Correction factor (CF)} = \text{average commercial yield} \div \text{average trial yield} \qquad (1)$$

This correction factor was subsequently applied to the trial dataset to adjust trial yields. The process was repeated for individual mill supply areas, and a correction factor was subsequently calculated for each area.

The trial yield dataset was further divided into on-station and off-station trials (i.e. on SASRI research stations or on growers' farms) and was compared to commercial yields to determine which type of trial corresponded more accurately to commercial values (1984 to 2006).

Stalk population (stalks/ha) and stalk weight (g/stalk) are variables that have been measured from variety trials since the inception of the Variety Evaluation Project. Stalk population is normally determined by counting the number of stalks per X metres (typically 8-10 m) of cane at a particular row spacing (typically 1.0-1.4 m, and 5-6 rows), expressed on a per hectare basis. Average stalk weight is determined by taking a sample of 12-16 stalks from each plot in a trial at harvest (Ramburan *et al*., 2007). Data from the 1999-2000 to 2004-2005 production seasons were used to determine estimated trial yields from destructive sampling (ETYds) using equation 2:

$$\text{ETYds (t/ha)} = (\text{stalks/ha x g/stalk}) \div 1\,000\,000 \qquad (2)$$

ETYds was then compared to actual trial yields determined from plot weights (ATYpw). This was done to investigate whether ETYds could be used to accurately predict ATYpw when ATYpw cannot be determined in the conventional manner, i.e. harvesting and weighing of each individual plot. Regression analysis was used to establish a relationship between ETYds and ATYpw. The regression equation produced was then validated against data from the 2005-2006 season (different dataset), where ETYds was compared to ATYpw to test the applicability of the equation. Average seasonal data from 1989-1990 to 2005-2006 were then used to compare four different datatsets:

- Average commercial yields from the industry.
- Actual trial yields measured from plot weights (ATYpw).
- Estimated trial yields from destructive sampling (ETYds).
- Estimated trial yields from destructive sampling transformed by applying the regression equation and the correction factor.

All dataset comparisons throughout the study were done using two sample unpaired t-tests and regression analyses (Genstat, version 10).

Results and Discussion

Trial data versus commercial data

Trial yields followed the same trends as commercial cane yields from 1979-2006 (Figure 1). Years of high and low cane yields in the industry were mimicked by high and low average cane yields in trials. However, trial yields have consistently overestimated commercial yields. Although trends in productivity were similar, these two datasets were significantly different from each other ($P<0.001$). The differences between trial and commercial cane yields for individual years ranged from 14 tons cane per hectare (t/ha) to 50 t/ha, with an average difference of approximately 30 t/ha (Figure 2). This suggests that on average, variety trial yields have been overestimating commercial yields by approximately 30 t/ha. This is in keeping with the general observations made by researchers and extension specialists in the

South African sugar industry. Although aware of a constant overestimation of commercial yields by trial yields, industry researchers have not previously attempted to quantify this difference.

The two datasets were used to calculate a correction factor of 0.7 according to equation (1). The mean commercial yield, as a percentage of mean trial yield was 70%, and this corresponds closely to the efficiencies of 85.5 and 76% obtained by Bissessur *et al*. (2007) and Davidson (1962), respectively. When the average trial yields were multiplied by the correction factor (CF) of 0.7, the new adjusted trial yields corresponded more accurately with the commercial yields and these two datasets now showed no significant difference (P=0.759) (Figure 1). The average difference between trial (with CF) and commercial yields now ranged between –17 and 14 t/ha (Figure 3), indicating that the CF of 0.7 was successful in adjusting trial yields to more meaningful and realistic levels. It is envisaged that such a correction factor could be used by extension specialists and researchers to adjust trial data that is thought to exaggerate local productivity trends. This may over time restore grower confidence in trial results, and lead to faster and more appropriate adoption of variety recommendations.

Correction factors were also calculated on a mill area basis, where all trials from a particular mill area were grouped and the average trial yields were compared to the average commercial yields for that mill area. CF's for the different mill areas ranged from 0.54 to 0.9 (Table 1). In all cases, the application of an appropriate CF to the trial data adjusted trial yields to correspond more accurately with commercial yields in the same mill area (data not shown). A positive linear relationship was found between the magnitude of the CF's and average trial yields from mill areas (data not shown). This suggests that in mill areas with high average yields, trial yields correspond more accurately to commercial yields (high CF's), while in areas of low yields, trial yields correspond less accurately to commercial yields (low CF's). This implies that variety trials in the South African sugar industry give a better prediction of actual commercial performance under higher potential conditions compared to lower potential conditions.

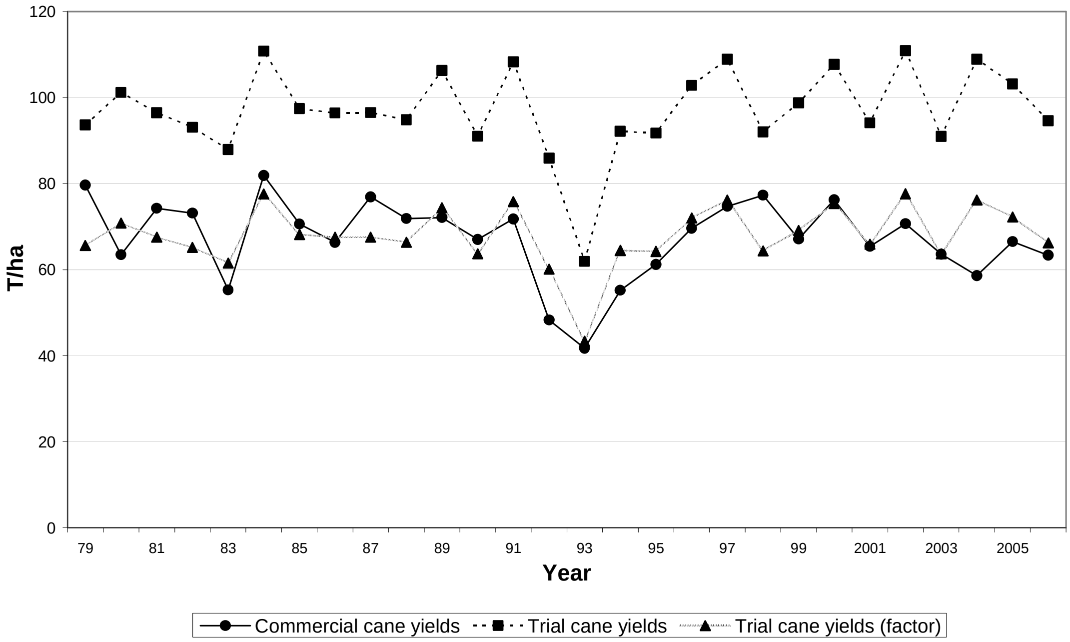

Figure 1. Average trial yields (with and without a correction factor) versus commercial yields from 1979 to 2006.

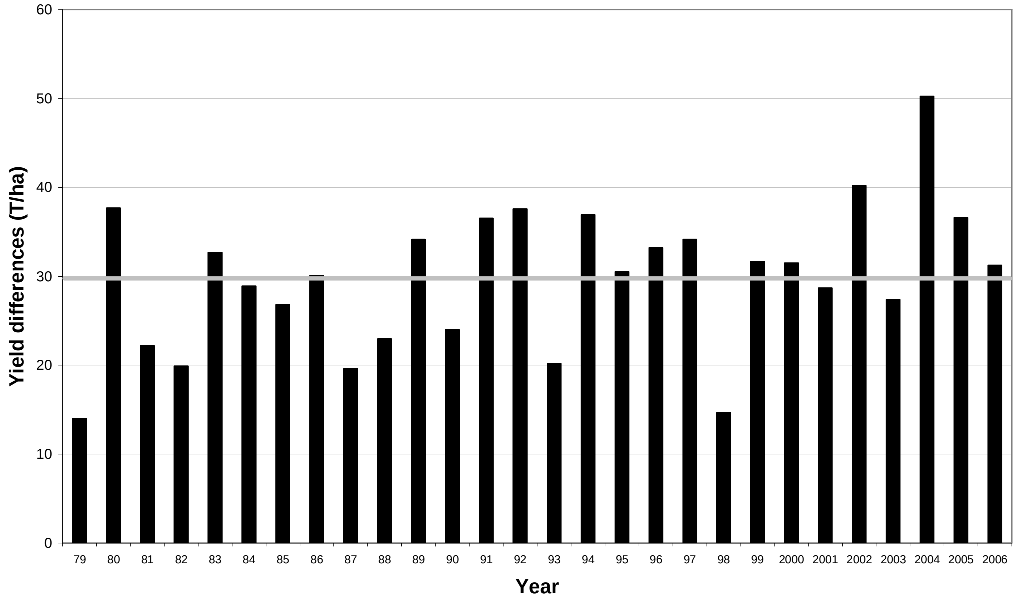

Figure 2. Differences in yield between trials and commercial production (1979 to 2006).

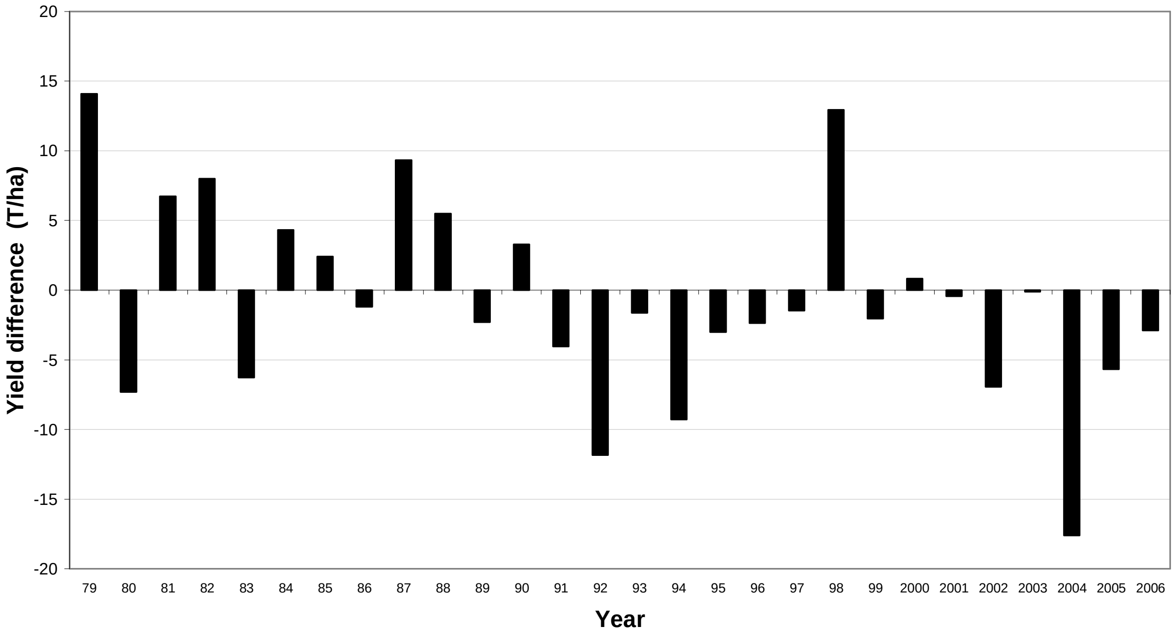

Figure 3. Differences in yield between trials and commercial production after the application of the correction factor (1979 to 2006).

Table 1. Average trial yields and the corresponding correction factor for each mill supply area.

Mill supply area	Average yield (t cane/ha)	Correction factor
Darnall	53.8	0.54
Entumeni	55.0	0.56
Umfolozi	69.4	0.63
Gledhow	49.8	0.66
Felixton	61.8	0.69
Maidstone	56.8	0.74
UCL Co Ltd/Noodsberg	85.0	0.74
Amatikulu	49.8	0.76
Pongola	91.2	0.77
Sezela	69.0	0.80
Eston	94.5	0.80
Komati	104.0	0.83
Umzimkulu	75.4	0.84
Malelane	84.9	0.90

On-station versus off-station trials

Average trial yields from 1984 to 2006 were retrieved from on-station (SASRI research farms) and off-station (grower farms) trials and compared to commercial yields for the corresponding years (Figure 4). The yields obtained from both of these sources followed the trends of commercial yields, but were significantly different from the commercial dataset ($P<0.001$). Linear regression was subsequently used to compare the two sources of trial data to commercial yield data (Figure 5a,b). It was found that off-station trials exhibited a stronger relationship (regression coefficient = 0.88, r^2=0.43) with commercial yields than on-station trials (regression coefficient = 0.62, r^2=0.29). This is due to the off-station trials being established on commercial fields under more or less similar representative conditions (Pillay, 1999), whereas the on-station trials are established on SASRI research farms, under good production conditions and with better general crop management. The results confirm the importance and relevance of grower-managed trials in predicting variety performance at the commercial level.

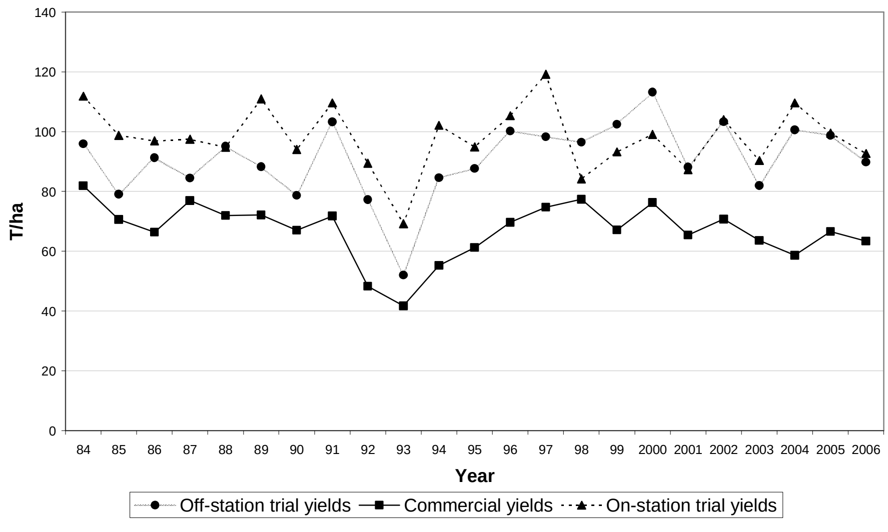

Figure 4. Average yields of on-station trials, off-station trials, and commercial production (1984 to 2006).

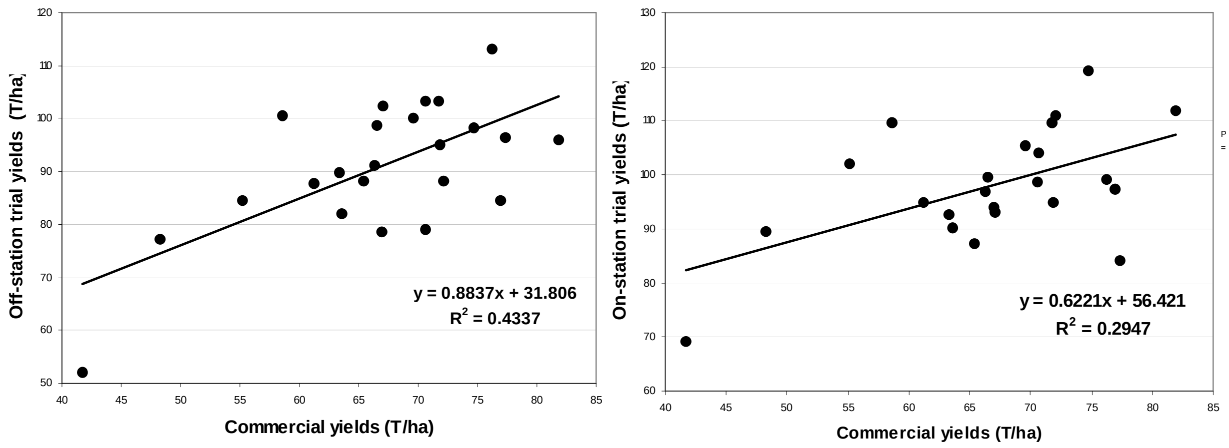

Figure 5. Linear relationship between yields of (a) off-station trials and (b) on-station trials and commercial production (1984 to 2006).

One of the perceptions amongst Sugar industry specialists in South Africa is that the plot ‘end-row’ effect (better growth on the periphery of the plot that results in enhanced plot yield) is one of the main factors contributing to exaggerated trial yields. In this study it was found that off-station trials that included end-row effects in plot weighing corresponded more closely to commercial yields than on-station trials where end-row effects were removed before weighing. This implies that end-row effects may not necessarily be the major contributor to the overestimation of yields. Other related factors may be contributing more to the overestimation of yield. The lower variability in smaller plots compared to the high degree of spatial variability in commercial fields may be a primary reason (Milligan *et al.*, 2007). Also, when choosing a site on which to establish a trial, there is often a high degree of bias towards favourable field conditions (uniform fields, better soils, flat seedbeds) and more prominent grower co-operators (Redshaw, 1999). This combination will more often than not produce higher yields. Furthermore, differences in the methodology used to determine cane yield for research and commercial purposes, together with the lack of reliable commercial data (Walker and Simmonds, 1981), may also exacerbate the yield gap between trial and commercial yields.

Estimating trial yields from destructive sampling

The relationship between ATYpw and ETYds (2000 to 2005) followed a significant exponential trend where ATYpw = 182.18 – 188.9 (0.991179^{ETYds}), with an r^2 value of 0.7 (Figure 6). At high cane yields (>130 t/ha) the relationship between ATYpw and ETYds was more variable, indicating that ETYds predicts ATYpw with less accuracy for high yield potential conditions. The exponential relationship also makes sense from a practical perspective, because it is unlikely that an estimated yield of 200 t/ha will result in an actual yield of 200 t/ha, as it would in a linear relationship model. Such high yields of cane are not common in South Africa, and the exponential relationship therefore captures this phenomenon fairly well.

When the exponential relationship was tested and validated against data from the 2005-2006 production season, a significant linear relationship was obtained, with an r^2 value of 0.66 (Figure 7). This suggests that the exponential relationship could be used to help predict trial yields accurately. From a practical perspective, when trials cannot be harvested and weighed due to the lack of labour or extremely wet conditions, yields can be estimated from stalk population and stalk weight, and then corrected as per the exponential equation, to predict actual yields more accurately.

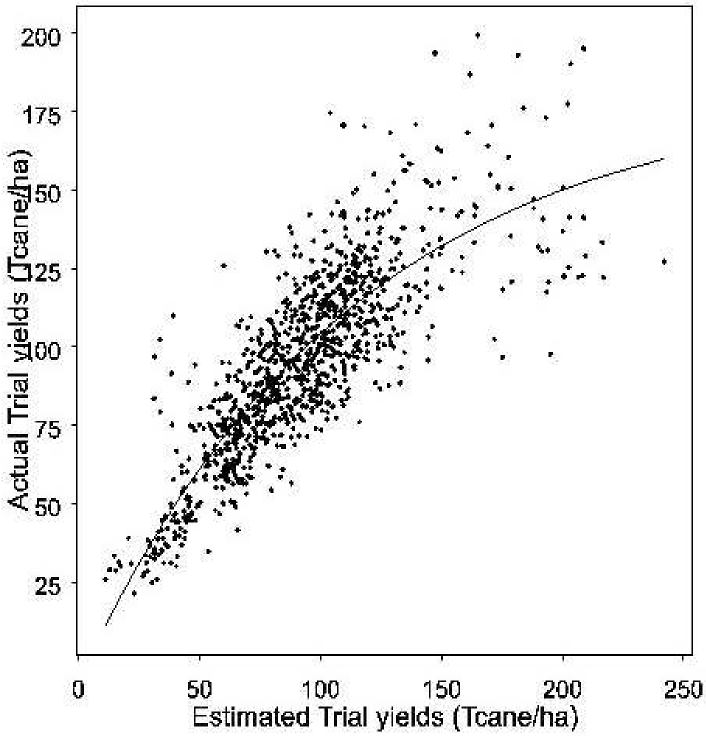

Figure 6. The relationship between actual trial yields (ATYpw) and estimated yields from destructive sampling (ETYds).

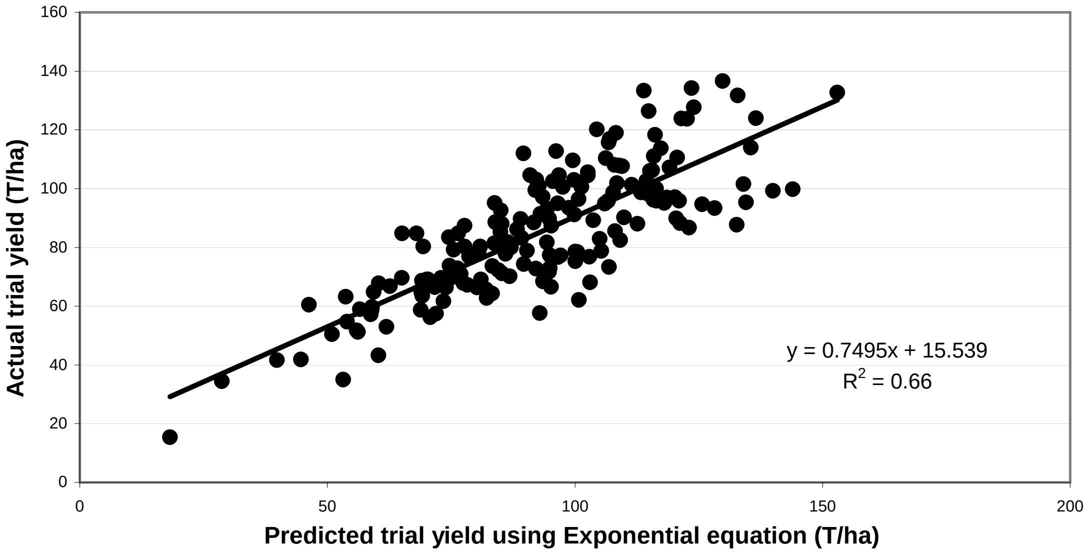

Figure 7. The relationship between actual trial yields (ATYpw) and yields predicted using the exponential equation for the 2005-2006 production season.

Estimated yields versus commercial yields
ETYds was compared to trial and commercial yields for the period 1990 to 2006 (Figure 8). ETYds followed the same trends as trial yields and also overestimated commercial yields ($P<0.001$). However, when the exponential equation and CF was applied, ETYds was adjusted to more realistic levels and was not significantly different from commercial yields ($P=0.890$). This suggests that the exponential equation, together with the CF, could be used as tools to adjust ETYds to more realistic levels where estimates of cane yield are necessary because of constraints such as shortage of labour.

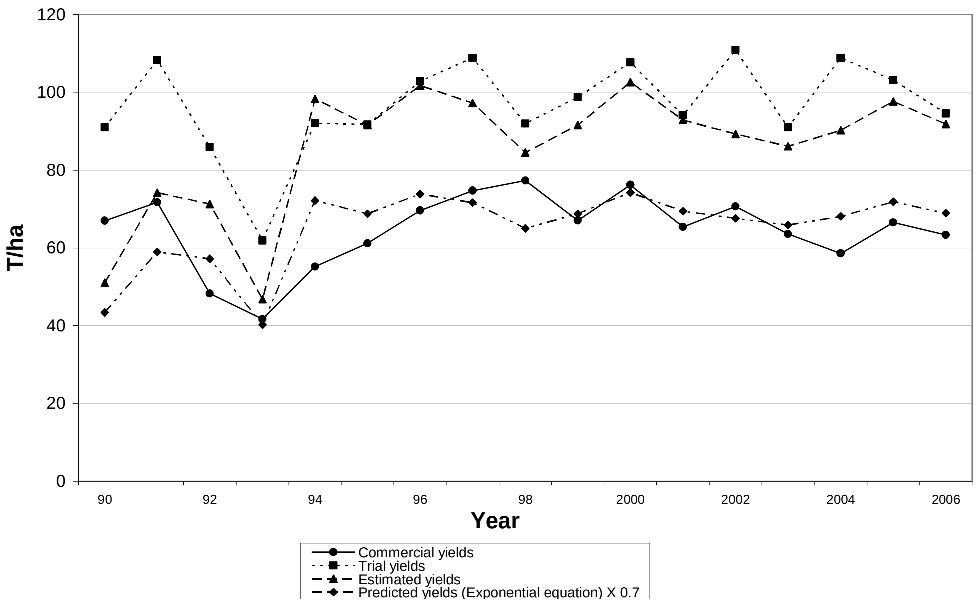

Figure 8. Comparisons of commercial yields, trial yields, estimated yields from destructive sampling, and predicted yields using the exponential equation and the correction factor.

Conclusion

This study has provided valuable insight into the relationships between trial and commercial data in the South African sugar industry, and has quantified the extent of disparity between commercial yields and trial yields. The correction factor(s) obtained from the study (at the mill or industry level) will be used as a practical tool to adjust trial yields to acceptable grower levels. The concept of using a correction factor to adjust for trial yields can be explained to growers, thus enhancing their confidence in attainable yields at the commercial level.

The study has also confirmed that on-station trials overestimate commercial yields to a greater extent than off-station trials. The better management practices and better growing conditions that are present in on-station trials can inflate the discrepancies between variety performance in trials and yields obtained commercially. This observation, together with a general lack of land on the SASRI research farms (land is often dominated by pre-release plant breeding trials), will shift the balance of the Variety Evaluation Project towards more off-station, grower-managed trials in the future.

Due to the increasing threat of labour shortages in the industry, it is likely that many variety trials will not be harvested and weighed in the traditional manner. Consequently, the estimation of trial yields from destructive sampling may become an established practice in the future. This study attempts to establish a relationship between actual and estimated cane yields. Further improvements on the exponential relationship put forward in this study can contribute to more accurate yield estimations from trials.

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