A tool for converting conventional sugarcane trial results into economic terms

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Abstract Results from sugarcane field trials are conventionally presented in cane and/or sucrose yield terms. The availability of a tool to convert conventional field-trial data into economic terms would enable researchers to rapidly perform economic calculations and routinely include economic considerations into recommendations to end-users. This paper outlines the nature of such a tool that was developed at the South African Sugarcane Research Institute (SASRI), and reports on its performance when tested across a series of sugarcane trials. The MS Excel-based calculator allows for the definition of treatments, together with the input of measured trial cane yields and cane quality defined as recoverable value content (RV%). Production factors and their related costs are listed sequentially from land preparation through to cane delivery to mills. Users are able to activate any given production factor depending on the type of trial being considered. Treatment differences (cost/ha) for that specific factor are then defined further. The tool considers all harvesting, loading, and transport costs associated with higher cane-yielding treatments, together with any product and application cost differences to calculate a gross margin (GM) for all treatments. Data from variety, chemical ripener, nematicide, mulch-retention, harvest-age, and crop-nutrition field trials were analysed using the calculator. Data input consisting of trial parameter set-up and definition of treatments were completed in under 10 minutes for each trial, and the GM of each subsequent crop in a trial could be calculated in under another 2 minutes. In general, the GMs were well correlated to RV yields when using current production costs. However, sensitivity analyses showed that increases in treatment costs, cane yield and its related harvesting and transport costs may offset future GM benefits of some treatments. Foliar application treatments generally produced much higher GMs compared with controls, even if product and application costs were doubled. Selected examples of the different applications of the calculator are illustrated and discussed. It is envisaged that the calculator will become a useful tool for researchers needing to improve the adoption of best management practices through economic reporting.

Key words Field trials, economics, gross margins, treatments

INTRODUCTION

Results from field trials are reported conventionally in terms of cane and/or sucrose yield. Given the high costs of production of sugarcane (planting, management, harvesting, transport), variable input costs and varying sugar prices, economic reporting of field trial results is also becoming more important. Higher cane/sucrose yields in sugarcane do not necessarily equate to higher profits. One of the difficulties with economic reporting is the time taken to conduct such analyses, and the issue of finding appropriate costs for different operations in various regions of an industry. Sugarcane researchers occasionally include economic assessments in their work (Rhodes et al. 2014). These are most often conducted manually, as once-off calculations. In some cases (e.g. multiple crops harvested), these calculations can become quite repetitive and time consuming for researchers. Furthermore, there is potential for duplication of effort by researchers across disciplines. A more strategic, sustainable approach may be to develop a generic economic conversion tool that can be used by researchers across disciplines. The availability of a tool to convert conventional field-trial data into economic terms would enable researchers to rapidly perform economic calculations and routinely include economic considerations into recommendations to end-users.

Other calculators have been developed, e.g. Econocane® (Wynne and Van Antwerpen 2004). Some limitations of the currently available calculators include high levels of complexity and specificity. The Econocane® tool, in particular, also focuses more on the specific agronomic practice of green-cane harvesting. In some cases, economic indices have been applied to conventional experiments, e.g. Australian plant breeding (Wei et al. 2008).

Some tools focus on calculating grower profitability or full farm budgets. An example is the Farm Economic Assessment Tool (FEAT) developed in Australia (Cameron 2005). Such in-house calculators and tools are often developed by local
canegrower associations in different industries. They may also be somewhat inappropriate (too complex) for field-based researchers wishing to evaluate the economic benefit of experimental treatments only. When presenting or reporting the benefits of agronomic treatments, researchers are more concerned with relative economics rather than accurately estimating grower profitability. The FEAT package has been used successfully to assess the realised value of RD&E to an industry as practices have changed over periods of time (Schroeder et al. 2009). However, a generic tool that allows for economic comparisons of a range of experimental agronomic treatments does not appear to be generally available.

Our objective is to outline the characteristics of an economic assessment tool for evaluating research results developed at SASRI, and to report on its performance and suitability to various types of sugarcane experiments.

**METHODS**

**Conceptual framework**

The tool was developed to enable comparisons of treatments at the individual crop (plant or ratoon) level of a trial. The two major inputs are experimental cane yields and cane quality, the latter defined as recoverable value content (RV%) according to the South African cane-payment system. The tool requires users to define all input costs associated with producing a crop of sugarcane (from planting through to mill delivery) for a particular cane-growing region. The variable costs due to specific agronomic treatments need to be entered separately from the costs that are constant across treatments. The differential costs associated with treatments may be defined in absolute terms, or in relative terms. Any subsequent effects of the agronomic treatments on other costs are accounted for within the model, e.g. the tool will account for higher harvesting and transport costs associated with higher cane-yielding treatments. The tool calculates a gross margin (GM) associated with each treatment in the trial. Although the tool was designed to cater for single factor experiments, multi-factor experiments can also be accommodated through appropriate treatment definitions. The tool does not allow for the inclusion of business running costs or loan repayment costs associated with whole-farm economics.

**Design**

The MS Excel-based tool consists of three essential input sheets, two intermediate calculation sheets, and two output sheets. The following is a description of the input sheets, in the sequence required to run an analysis:

**Trial information sheet** - The user defines the number of treatments, the number of replications, and allocates treatments to plots in the experiment (via drop-down or copy/paste functions). Plot level cane yields and RV% are pasted into relevant columns. The appropriate RV price is also defined at this point.

**Cost definition sheet** - The user selects the "production region" and the "crop" (plant or ratoon) relevant to the experiment from drop-down boxes. A list of costed items is populated with relevant costs according to the above choices. The user then chooses which of the cost items vary due to the agronomic treatment being investigated in the trial. The chosen cost items are carried forward to the treatment cost definition sheet for further definition.

**Treatment cost definition sheet** - The costs associated with each cost item that varies between treatments are defined. The costs are defined in either absolute or relative terms, e.g. the most expensive of three chemicals can be used as a base-line cost, with the other two then expressed as a percentage (fraction) of that cost. Most cost differences among treatments are defined through simple "yes/no" choices.

Once all treatment and baseline costs are defined, the tool summarizes the average cane yields, RV yields, expenses, and GMs associated with each experimental treatment.

The tool was used to evaluate the economic differences among treatments in a range of variety, fertilizer, fungicide, insecticide, nematicide, chemical-ripper, residue-retention, and harvest-age trials.

**RESULTS AND DISCUSSION**

The average time taken to set up a new analysis of a trial was approximately 10 minutes. Each subsequent ratoon of the same trial could be analysed in approximately 2 minutes. Additional sensitivity analyses relating to the cost of labour, cost of transport, and product costs were also easily evaluated using the tool. The following are examples of different
applications of the tool that have provided useful insights into the economics of agronomic treatments, highlighting the flexibility of the tool.

Variety trials

Results from a series of conventional variety trials were analysed using the tool. In these analyses, cost items that varied among varieties included time to canopy (affecting the number of weed control sprays needed), cane, RV yield, and differences in lodging characteristics (affecting harvesting, handling and transport costs). In all trials analysed, the GM rankings of varieties were compared with their RV yield rankings. Figure 1A shows an example of results from a single trial that were analysed using the tool. In this trial, variety N48 is the highest RV yielding variety, but it is not the most profitable. Variety N35, which was ranked second in terms of RV yield, achieved a higher GM than N48. This may be linked to the higher cane yields and lodging associated with N48, which had an effect on transport costs. Similarly, N31 shows higher RV yields than N40, but N40 shows a higher GM than N31. This may be due to the higher sucrose content and lower cane yields of N40 versus N31. The results show that grower recommendations for profitability may actually be different to recommendations based on RV yields. This illustrates one of the key envisaged functionalities of this tool for improved recommendations.

In terms of the sensitivity analyses, Figure 1B shows the effects of varying distances to the mill (a factor related to transport costs) on the GM of two varieties evaluated in a trial. Variety N36 produces higher GMs than N40 when the distance to the mill was under 20 km. However, when the distance exceeded 20 km, variety N40 became more profitable than N36. These differences relate to the characteristics of the varieties that affect transport costs, i.e. the higher cane yields produced by N36 becomes a negative factor that influences GMs when the transport costs of such higher yields are increased. Once again, this shows that variety recommendations for growers would need to be adjusted based on these transport costs. This type of analyses would be laborious and time consuming under normal circumstances, but was relatively simple and quick using the tool.

**Fig. 1.** Average RV yields and gross margins (GMs) of (A) varieties in a variety trial, and (B) the effect of varying distances to the sugar mill on GM of two varieties evaluated in a variety trial.

Mulch-retention trials

In South Africa, concerns around additional costs associated with labour and transport in a green-cane harvesting system has limited adoption of this practice. Additionally, concerns around variable responses under some soil types and seasons have also led to limited adoption (Wynne and Van Antwerpen 2004). We used the economic conversion tool to illustrate the economic benefits of mulch retention, considering all additional production costs involved. Figure 2 shows the GMs associated with a burnt versus a mulched (trash) treatment in a long-term burning and trashing trial in South Africa. These results, which were presented to growers, illustrate that the economic response to mulching was not consistent across
harvesting years. However, on average, mulching resulted in a ZAR3416/ha benefit above a conventional burnt system over a period of 8 years. This economic validation of mulch retention is seen as a key to encouraging the adoption of this practice.

The economic analyses of multiple years of data from trials is normally time consuming and repetitive. The tool permitted such analyses within 10 minutes. The tool also allowed for hypothetical scenarios to be run, which showed that the mulch treatments remained profitable despite a doubling of labour costs.

Harvest-age trials

In the coastal region of the South African sugar industry sugarcane is harvested between 12 and 20 months of age. The ‘optimal’ harvest age to maximise profits has been a contentious issue for many years (Ramburan 2015). We used the economic tool to analyse a series of trials evaluating RV yields of different varieties harvested at either 12 or 18 months of age. An example of the results obtained from one of these trials is shown in Figure 3. In this case, the RV yields of most varieties was significantly improved when the cane was harvested at 18 months of age compared to 12 months of age (Fig. 3A). However, the tool showed that harvesting three 12-month crops of some varieties was actually more profitable than harvesting two 18-month crops (Fig. 3B). In this example, it is clear that the additional production costs associated with growing an additional (lower RV yielding) crop is justified, over the three-year cycle. This example showed that the tool can evaluate the economics of different cutting cycles, taking into consideration additional yields, planting, harvesting, and transport cost dynamics of the different scenarios.

Chemical-ripening trials

For chemical ripener to be economically effective, increases in RV yield, and not only cane quality (RV%), must be achieved. Although increases in RV% through the use of ripeners have been demonstrated extensively, the suppression of stalk and/or leaf growth by these chemicals is known to potentially reduce cane yield (Van Heerden et al. 2014). Therefore, a frequently asked question by growers is to what extent the loss (or perceived loss) of cane yield may reduce the economic benefit associated with chemical ripening.

Here, we used the economic conversion tool to determine how much cane yield could potentially be sacrificed, whilst still maintaining profitability. In a recent field experiment with variety N16 the chemical ripener treatments Etephen (Eth), Fusilade Forte (FF), and a combination of both these chemicals (Eth + FF), increased RV% by 1.1, 1.4 and 2 percentage units, respectively, over the unripened control, whilst reducing cane yield by a maximum of 4.9 t/ha (results not shown).
Fig. 3. (A) Average recoverable value yields per crop of six varieties harvested at 12 months of age or 18 months of age, and (B) the annualised gross margins of those varieties when harvested as three 12-month crops or two 18-month crops.

The economic analysis showed that cane yield losses of up to 9, 12 and 15 t/ha for the Eth, FF and Eth + FF treatments, respectively, would still have resulted in increased gross margins relative to the control (Fig. 4). Considering that the actual cane yield losses in the field experiment did not exceed 4.9 t/ha, our analysis showed that in this case all the ripener treatments were highly profitable, and that the cane yield losses were well below the profitability thresholds identified with the economic conversion tool. This example illustrates an application of the tool to provide assurance to growers of the economic benefits of a management practice.

Fig. 4. Change in gross margin (relative to control) for different cane yield loss scenarios in the ripener treatments Ethephon (Eth), Fusilade Forte (FF), and a combination of both these chemicals (Eth + FF).
Nematicide trials

The use of a nematicide is a substantial investment and, thus, any associated yield increase must warrant its use. The tool provides a way to assess if the yield increase due to nematicide is in fact economical, taking into account all production factors.

Figure 5 shows the change in cane yields associated with nematicide application in a variety (6 varieties) by nematicide (treated versus untreated) field trial harvested in 2015. All varieties, except variety N56, responded to nematicide and showed an increase in cane yield. However, based on the economic analysis tool, only three varieties (N55, N52 and N55) showed a profit associated with nematicide application (Fig. 6). The most obvious difference was with variety N47. This variety had a yield increase of 7 t/ha due to nematicide application (Fig. 5), but resulted in lost revenue of ZAR2557/ha (Fig. 6). In this case the increase in revenue from the increased cane yield of N47 was not sufficient to offset the cost of the nematicide and increased transport cost of such higher yields. In such circumstances, recommendations to growers based on cane yield responses would be inaccurate, as the economic response shows an opposite trend. This highlights an important application of the tool to evaluate the economic benefits of a soil-applied pesticide.

Fig. 5. Change in yield of six varieties due to nematicide treatment.

Fig. 6. Change in revenue associated with nematicide treatment of six varieties.
Fertilizer trials

Conventional fertilizer rate trials also provided data for economic analyses. In this example, the GMs of five nitrogen (N) application rates used within a particular trial were calculated. In general, the GMs followed the same trends as RV yields (Fig. 7A), with the 140 kg N/ha treatment being most profitable. A supplementary analysis conducted on this data explored the effects of increasing N prices on the GMs of different N treatments (Fig. 7B). The results showed that the 140 kg N/ha treatment was more profitable than the other treatments, but that the 70 kg N/ha treatment converges with the 140N as the price of N increases up to five-fold (Fig. 7B). The 210 kg N/ha treatment (alone or split) would become uneconomical if the price of N increased five-fold. Even though such large increases in N prices are unlikely in the near future, this example nevertheless illustrates how the tool can be used to identify scenarios that may cause agronomic practices to become uneconomical in future. Alternatively, such analyses can provide assurances that particular agronomic treatments are at least economical for the foreseeable future.

CONCLUSIONS

The economic conversion tool was tested on various types of sugarcane experiments that are routinely conducted in a sugarcane research environment, and was found to be suitable for all applications. Researchers from different disciplines have found the tool to be very user-friendly and efficient. In most cases, economic analyses beyond those originally intended were also conducted with ease.

The tool provides a framework and/or incentive for researchers to go beyond the traditional yield-based analyses associated with sugarcane agronomic experiments. It is envisaged that this will have a significant impact on the uptake of best management practices by growers. The tool can also be used to conduct retrospective analyses of past experimental results that were not evaluated economically due to time constraints or a lack of understanding of production cost issues. In this respect, the tool also assists researchers to become more acquainted with the business or operational aspects of sugarcane production, which will benefit knowledge exchange activities with growers.

The tool requires simple annual updates of costs associated with operations in different regions of the industry. Simpler versions of the tool may be developed in future for use by extension specialists or growers needing access to quick calculations of expected economic returns for different agronomic options.

REFERENCES

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Un outil pour convertir les résultats conventionnels d’essais en canne à sucre en termes économiques

Résumé. Les résultats d’essais au champ sont habituellement présentés en rendements canne et/ou sucre. La disponibilité d’un outil pour convertir ces données en données économiques permettrait aux chercheurs de réaliser rapidement des calculs économiques et d’inclure en routine des considérations économiques dans les recommandations aux utilisateurs finaux. Cet article souligne les caractéristiques d’un outil développé par le South African Sugarcane Research Institute (SASRI), et présente ses propriétés quand il est testé dans une série d’essais en canne à sucre. Le module de calcul Excel permet la définition des traitements, la saisie des rendements canne et de sa qualité en terme de teneur en sucre récupérable (RV%). Les paramètres de production et leurs coûts sont listés séquentiellement de la préparation du sol à la livraison de la canne aux usines. Les utilisateurs peuvent agir sur n’importe quel facteur de production en fonction du type d’essai. Les différences entre traitements (coût/ha) pour un facteur spécifique sont ensuite définies. Pour calculer une marge brute des traitements, pour tout mode de récolte, l’outil prend en compte les coûts de chargement et de transport associés à de hauts rendements en canne, quel que soit le produit et les différents coûts d’application. Des données d’essais variétaux, de maturateurs, de nématicides, de conservation du paillis, d’âge de récolte, de fertilisation, ont été analysées par le simulateur de calcul. Les données, concernant les paramètres de l’essai et la définition des traitements ont été saisies en 10 minutes pour chacun des essais et la marge brute de chaque récolte pour un essai a pu être calculée en deux minutes. En général, les marges brutes étaient bien corrélées au sucre récupérable pour les coûts de production connus. Des analyses plus fines ont montré qu’avec des augmentations du coût des pratiques, le rendement en canne ainsi que les coûts de récolte et de transport qui en résultent peuvent affecter les marges brutes de certaines pratiques. Des applications d’engrais foliaires ont généralement produit de plus importantes marges brutes que les témoins, même si les produits et les coûts d’application doublaient. Des exemples choisis de diverses applications du module de calcul sont illustrées et discutées. Il est envisagé que le module de calcul soit un outil utile pour les chercheurs ayant besoin d’améliorer l’adoption de meilleures pratiques de gestion dans un cadre économique.

Mots-clés: Essais au champ, économie, marges brutes, traitements

Una herramienta para la conversión a términos económicos los resultados convencionales de ensayos de caña de azúcar

Resumen. Los resultados de ensayos de campo de caña de azúcar generalmente se presentan en términos de rendimiento de caña y/o rendimiento de sacarosa. Disponer de una herramienta para convertir estos resultados en términos económicos permitiría a los investigadores realizar rápidamente cálculos e incluir de manera rutinaria consideraciones económicas en las recomendaciones para los usuarios finales. En este trabajo se describe la naturaleza de dicha herramienta que fue desarrollada en el South African Sugarcane Research Institute (SASRI) y los informes sobre su desempeño realizado a través de una serie de ensayos de campo. La calculadora basada en MS Excel permite la definición de los tratamientos, junto con la entrada de los rendimientos de caña de los ensayos y calidad de la caña definida como contenido de valor recuperable (VR%). Los factores de producción y sus costos relacionados se enumeran secuencialmente desde la preparación del terreno hasta la entrega de caña al ingenio. Los usuarios pueden activar cualquier factor de producción dado en función del tipo de prueba considerado. Las diferencias entre tratamientos (costo / ha) para ese factor específico son entonces definidos. La herramienta considera todos los costos de cosecha, alce y transporte asociados con los tratamientos de más alta producción junto con las diferencias de costos de productos y aplicaciones para calcular un margen bruto (MB) de todos los tratamientos. Los datos de la variedad, madurador químico, nematicida, retención de residuos (mulch), edad de cosecha, y pruebas de campo de nutrición vegetal se analizaron usando la calculadora. La entrada y organización de datos de los parámetros de los ensayos y la definición de los tratamientos se completaron en menos de 10 minutos para cada ensayo, y el MB de cada cultivo posterior en un ensayo se podría calcular en menos de 2 minutos más. En general, los MBs se correlacionan bien con los rendimientos de VR al utilizar los costos de producción actuales. Sin embargo, el análisis de sensibilidad mostró que aumentos en los costos de los tratamientos, rendimiento de caña y su costo asociado de cosecha y transporte pueden compensar futuros beneficios de GM de algunos tratamientos. Los tratamientos de aplicaciones foliares generalmente producen más altos MBs en comparación con los testigos, incluso si se duplicaran los costos del producto y de aplicación. Se ilustran y discuten algunos ejemplos seleccionados de las diferentes aplicaciones de la calculadora. Se prevé que la calculadora se convertirá en una herramienta útil para los investigadores que necesitan mejorar la adopción de las mejores prácticas de manejo a través de presentar información económica de sus resultados.

Palabras clave: Ensayo de campo, economía, márgenes brutos, tratamientos