

South African Sugar Technologists' Association

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SEVENTY-NINTH ANNUAL REVIEW OF THE MILLING SEASON IN SOUTHERN AFRICA (2003 -2004)

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Abstract

Performance, throughput and other relevant aspects of the sugar industries in southern Africa are presented and discussed. Data from sugar mills in South Africa, Swaziland, Zimbabwe and Malawi are included. The cane crop and factory performance are discussed, with Recoverable Value trends particularly mentioned. In contrast to the excellent 2002-2003 season, the 2003-2004 season suffered from drought conditions in several areas and a severe late frost in the Midlands areas. These contributed to a crop of less than 21 million tons of cane, compared to 23 million tons in 2002-2003, and poor cane supply and poor cane quality late in the season, leading to processing problems at some factories.

OVERVIEW OF RÉUNION SUGAR INDUSTRY

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Abstract

On Réunion Island, the sugar industry plays an important role in the agricultural sector, not only in terms of production and export revenue, but also in regard to the number of people it employs. The sugar industry accounts for 27% of the agricultural production on the island, and provides a source of income for 5000 small-scale farmers. Sugarcane covers 26 500 hectares, and around 2 million tons of sugarcane is crushed each year by the two mills on the island. Moreover, sugarcane plays a significant environmental role as it helps to reduce soil erosion and to treat livestock effluent. It also provides energy resources in the form of 22% of the island's electricity and as most of the crop is harvested as green cane, it contributes to green tourism and landscape quality.

However, over the past 10 years, the Réunion sugar industry has had to face the difficulties of available arable land decreasing because of urbanisation, an increase in production costs, strong currency and environmental pressures. The industry is thus looking for solutions that will improve profitability while dealing with difficult conditions such as steep slopes that limit mechanisation, the large diversity in farm sizes and production systems, and stricter environmental regulations.

Although the industry is highly subsidised, permanent expansion and efforts have been made to maintain the industry. Technical, organisational and economic solutions have been developed in terms of mechanisation, transport costs, varieties adapted to various climatic conditions, irrigation and regional planning. This paper gives a detailed overview in this context and its perspective.

RENEWABLE ENERGY: AN OPPORTUNITY FOR THE SOUTH AFRICAN SUGAR INDUSTRY?

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Abstract

In the South African sugar industry, both co-generation and the production of fuel alcohol are considered to be uneconomical. Although this is probably true at present, it might change in the near future due to changing market opportunities, environmental considerations, technological developments and an increasing demand for energy. The South African Government targets 10 000 GWh renewable energy by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electrical technologies such as solar water heating and bio-fuel. This presents an opportunity for the South African sugar industry in terms of value addition and diversification and reduces its exposure to the world sugar market. To seize this opportunity the industry has to be pro-active both in laying the political and technical foundations. This paper looks at the possible prospects of renewable energy for the South African sugar industry.

ASPECTS OF THE EFFECTS OF SILICA DURING CANE SUGAR PROCESSING

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Abstract

Silica is a major component of soil and is an essential element for the sugarcane plant. It can exist in juice as a solute, as a colloid and as distinct particles. Its chemistry is complex; it reacts with aluminium, calcium, magnesium, potassium, iron and with organic polyphenols.

Factory streams contain soluble silica, which is present naturally in the cane. There is however, evidence of contamination from soil and clay, entering the mill with the cane. This contamination could add relatively large quantities of silica, of aluminium and of iron to the juice.

Poor quality lime can contain much soluble silica, which is then transferred to the juice.

Silica, aluminium and iron have been found to be major components of the inorganic content of clarifier muds, of the suspended matter in a turbid clear juice and of the suspended matter in a poor filtering raw sugar. These three species can also be major constituents of evaporator scale.

The paper discusses the points mentioned above, and presents available data relevant to the South African industry. It also comments on the impacts of silica during clarification and on sugar quality. The difficulties associated with the determination of silica in sugar products are mentioned.

THE PREDICTABILITY OF CANE PRODUCTION IN THE SOUTH AFRICAN SUGAR INDUSTRY USING SEASONAL CLIMATE OUTLOOKS AND THE CANESIM YIELD FORECASTING SYSTEM

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Abstract

Timely and accurate yield forecasts prior to and during the milling season present opportunities to improve various industry activities, such as milling operations, international trade and agronomic optimisation. The Canesim model-based yield forecasting system was used to quantify prediction skills at different times of the year, using historic climate data and a history of seasonal climate outlooks from the South African Weather Services. Yield prediction skill was low in September prior to the milling season (11%), but increased significantly towards March (36-43%). Some results showed that predictions in irrigated areas can still be improved significantly. Prediction skills were improved by 2% to 12% when seasonal climate outlooks issued at the beginning of the year (January to May) were used. Results also suggest that some mills may benefit more than others from climate outlooks.

THE SUGAR LOGISTIC IMPROVEMENT PROGRAMME (SLIP): AN INITIATIVE TO IMPROVE SUPPLY CHAIN EFFICIENCIES IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

A logistics chain in the South African sugar industry has been defined as the different agents responsible for growing, hauling and milling sugarcane.

Inefficiencies in a logistics chain can be broadly classified into two categories:

- Individual inefficiencies associated with an inappropriate technology and/or the management practices of individual members of a logistics chain.
- Collective inefficiencies associated with inadequate teamwork and a lack of co-operation between members of a logistics chain.

Inadequate information is usually the primary reason for both inefficiencies. Supplying best practice information to individual logistics chain members will to some extent alleviate individual inefficiencies, where adoption rates will be demand-led, i.e. the decision to 'change' is made by the individual. Supplying best practice information and mill area comparisons will also help alleviate collective inefficiencies, but adoption will need to be supply-led, i.e. the decision to 'change' needs to be made by the logistics chain as a group. This necessitates some degree of proactive leadership.

The Sugar Logistics Improvement Programme (SLIP) was designed to capture logistics chain information in a number of different mill areas, and to identify best practice. Dissemination of this information via various reports to individuals in the logistics chain is intended to address inefficiencies by meeting information demands. Collective inefficiencies are addressed through the establishment of local mill area 'Efficiency Committees' (comprised of growers, hauliers and the miller), which empower local leadership to make beneficial changes to the logistics chain that will foster improved team work and co-operation between individual logistics chain members.

This paper describes how SLIP evolved, how data is collected, analysed and disseminated, and some of the progress made to date in terms of efficiency improvements. Some of the more innovative best practices are described, and new developments are discussed.

VALUE AND FEASIBILITY OF ALTERNATIVE CANE SUPPLY SCHEDULING FOR A SOUTH AFRICAN MILL SUPPLY AREA

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Abstract

In South Africa, sugarcane is delivered to the mill uniformly over the milling season and across all supply areas. This delivery schedule does not exploit the cane quality patterns, represented by the 'recoverable value' (RV) of sugar, which shows distinct regional trends, primarily due to climate differences and resulting differences in agronomic practices. A 2002 study conducted in the Sezela mill supply area showed that total RV production could be increased by 1-5%, by dividing the mill supply area into four homogenous zones and adapting allocation according to cane quality variations. Based on these positive results, a second study was requested by the Mill Group Board to assess the feasibility of the supply scenarios. A 2003 study focused on the analysis of (i) delivery curves per sub-area, (ii) inter-annual variations in quality within the supply sub-areas determined in 2002, and (iii) available capacities along the supply chain, i.e. harvest, transport and milling. Both delivery and quality curves showed a fairly stable profile from one year to another. Deliveries increased progressively during the first month of harvest and decreased quickly from the beginning of the last month onwards. Inland cane supplies usually showed a more stable quality than coastal cane during the first half of the season. Extra capacities were available all along the chain, although the amounts varied from one stakeholder to another. On average, growers were able to double their daily ratable delivery, while hauliers could increase their capacity by 35%. These results were used to design and simulate scenarios similar to the real supply chain management. They took into account the quality variations between Inland and Coastal zones and the impact of stalk borer on Coastal cane quality. Both scenarios showed RV gains of 1-3%. However, implementing the proposed changes would impact differently on growers' incomes according to their location in the supply area. This statement implies further investigation on the relationship between cane payment system and cane supply organisation.

REDUCTION OF SUGAR LOSS DUE TO ‘CUT-TO-MILL’ DELAY BY THE APPLICATION OF A UNIQUE NEW CHEMICAL COMPOSITION CALLED SUCROGUARD

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Abstract

In India, the loss of sucrose content in cane as a result of ‘cut-to-mill’ delays can be extremely high during the summer months. A novel chemical formulation, Sucroguard, developed and patented in India, was tested to determine its effectiveness in controlling post-harvest cane deterioration. Results showed that a 10 ppm dose reduced invert sugars and tiratable sugars in primary juice, and reduced the total mesophilic bacterial count by 50%. It was found that the use of Sucroguard could result in a net benefit per million tons of cane of US\$720 000.

MINIMISING TRANSPORT COSTS THROUGH OPTIMAL UPGRADING OF ROADS AND LOADING ZONES

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Abstract

Infield to zone transportation with agricultural tractor-trailer units may incur costs of up to nine times those of long distance truck-tractor units. This necessitates the implementation of an optimal cane extraction road network. This paper describes formulas derived to evaluate whether the construction of additional roads and loading zones could enhance a farm's profitability. The formulas were subsequently applied in a case study typical of a 250 ha commercial sugarcane farm in South Africa, to quantify the technique's economic value and to demonstrate additional practical constraints. Transport savings were calculated at R23 000 per annum, and costs incurred on capital expansion was recovered after six crop cycles (ratoons). The results suggest that significant reductions in transport costs can be achieved in the South African sugar industry, especially by increasing the number of loading zones on existing roads. The case study did, however, identify several other factors, such as topography, cash flow requirements and vehicle utilisation issues that may alter road upgrading decisions. This work has been based on similar analyses currently under way in the South African timber industry.

MAKING HARVESTING GROUPS WORK: LESSONS FROM MEGATONS

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Abstract

The Mpumalanga cane growing region is characterised by harvesting groups using direct haul transport systems to the mills. A major drawback to infield loading and direct-haul is the resulting soil compaction and stool damage, which has been documented in sugar industries worldwide. Megatons (Pty) Ltd is a harvesting and transport group that was formed by a group of growers committed to long-term high quality cane yields with minimal infield damage. The group have opted for purpose-built, infield tractor/trailer combinations fitted with low pressure, high flotation tyres. The ability of the haulage equipment to minimise compaction and work in adverse infield conditions is an important consideration in a performance driven industry where growers are paid for delivering fresh cane in a contracted length of milling season. A comprehensive computer program manages harvesting and transport logistics. By combining an efficient logistics programme and purpose-built direct haulage equipment, Megatons is able to optimise machinery use and vehicle efficiencies, and minimise infield damage.

WHY DOES SUGARCANE GROW SLOWLY?

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Abstract

It had seemed, from juxtaposing results in a number of papers, such as those of Bull and Glasziou (1975), Begg (1965) and Wilson *et al.* (1973), that sugarcane grows more slowly than some other tall tropical grasses. To assess the significance of this with respect to sucrose production, unpublished data of RJ Haslam was used to directly compare sugarcane with Napier grass (*Pennisetum purpureum*), a tropical grass which is morphologically similar and is also vegetatively propagated, but produces little sugar.

YIELDS AND ESTIMATED ECONOMIC RETURNS FROM USING ETHEPHON TO SUPPRESS FLOWERING IN ANNUALLY HARVESTED SUGARCANE

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Abstract

When sugarcane flowers, vegetative growth is terminated and this can lead to yield losses. Applied ethephon disrupts the flowering process, thereby potentially mitigating the effects of flowering. The results from using ethephon to suppress flowering in several experiments are reported. They show that ethephon could have large negative effects on yields of annually harvested crops when there is no flowering. Collated results from publications show a linear relationship between sucrose yield response to ethephon and flowering incidence. Probabilities of flowering incidence were calculated, using criteria derived from historical temperature and water status. Probabilities, for example, of profuse flowering were 0.33 for northern irrigated crops and less than 0.1 for moderate flowering in dryland crops. The economic benefits from applying ethephon either (i) as a regular annual treatment or (ii) only when flowering is predicted, were calculated using specific assumptions. The analysis showed that in irrigated crops annual applications would be worthwhile for moderate and profuse flowering cultivar types. Shy flowering cultivars would require applications to be made only in years when flowering is predicted. These benefits can be realised only when ethephon is registered for flower suppression. In dryland cane regular ethephon applications are not justified when crops are harvested annually. In these crops, the benefits from targeted applications would be small thus the research needed to accurately predict rainfall and temperatures for February each year, may not be justified. These results need to be interpreted with caution because several factors, listed in the text, have not been considered in the analysis.

PERFORMANCE OF VARIETIES N14 AND NCO376 IN THE SOUTH-EAST LOWVELD OF ZIMBABWE

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Abstract

Varieties NCo376 and N14 are the most widely grown varieties in Zimbabwe and are used as control varieties in the selection programme. The success of NCo376 was due to its high yield potential throughout the year and its ability to maintain good yields, even in advanced ratoons. A study was done to compare the performances of N14 and NCo376 in the South-East Lowveld of Zimbabwe, using data from 1985 to 2003. A significant decline in the area planted to NCo376 took place in 1985 with the release of N14, and again in 1996 when ZN varieties began to be released. A stability analysis showed that yields of N14 responded better to favourable growing conditions than those of NCo376, although NCo376 accumulated sucrose better under favourable conditions. Of the two varieties, N14 produced much higher cane, ERC % cane and sugar yields than NCo376 in early to mid-season harvested cane. Both varieties had high ratooning ability, with N14 having a distinct advantage from the plant crop to the third ratoon. Variety N14 produced superior cane and sugar yields from 1985 to 2003.

DIFFERENCES IN CANOPY DEVELOPMENT OF TWO SUGARCANE CULTIVARS UNDER CONDITIONS OF WATER STRESS: PRELIMINARY RESULTS

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Abstract

The effect of water stress on canopy development of sugarcane cultivars N22 and NCo376 was evaluated in a rain shelter facility at the South African Sugar Association Experiment Station at Mount Edgecombe. The crop was grown under unstressed conditions for four months. Subsequently, water was withheld from one half of the trial for a period of 42 days. Soil water content in the stressed plots decreased from field capacity of 26% at the start of drying to 15% on day 15, and a permanent wilting point of 10% at approximately day 40.

Shoot survival in N22 was more sensitive to water stress than in NCo376. Water stress caused a simultaneous reduction in leaf appearance rate and an increase in leaf senescence rate, and consequently reduced green leaf numbers markedly in both cultivars. Leaf senescence appears very sensitive to water stress, with increases apparent at high relative soil water content (RSWC). Interception of plant available radiation was not as sensitive to water stress as leaf area, and in both cultivars decreased only after RSWC dropped below 0.5.

NCo376 was able to maintain canopy development processes longer under conditions of increasing water stress, and thus maintained a higher green leaf area index for longer than N22. This was achieved by extracting more water from the profile than N22, thereby maintaining a high turgor for longer, and supporting growth processes for longer.

The information obtained in this study will be used to refine and test crop canopy algorithms in crop models. This will allow better application of models to assist management of sugarcane production, especially under conditions of limited water supply.

STRATEGIES USED FOR VARIETY SELECTION IN THE BREEDING PROGRAMME AT THE ZIMBABWE SUGAR ASSOCIATION EXPERIMENT STATION

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Abstract

Sugarcane breeding is expensive because the plant is perennial and the frequency in obtaining superior clones is low. Plant breeding involves developing strategies that will increase the probability of identifying superior varieties. This paper discusses the strategies used to select varieties with high sugar yield, good disease and pest tolerance and adaptable to the South-East Lowveld of Zimbabwe. Potential strategies for the future are described. In the Single Stools and Single Lines stages (unreplicated), the strategy is to discard all genotypes with undesirable traits. In the Variety Observation Trials, Advanced Variety Trials and Pre-release Variety Trials (replicated stages) the strategy is to select those varieties that show an advantage over the control cultivars (N14 and NCo376) in yield, cane quality, pest and disease tolerance and ratooning ability. Future strategies could focus on molecular genetic markers, physiological genetic markers and possibly replicating varieties at the single lines stage.

PROGRESS AND PROSPECTS FOR MOLECULAR BREEDING IN THE SOUTH AFRICAN SUGARCANE VARIETY IMPROVEMENT PROGRAMME

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Abstract

Commercial sugarcane varieties are polyploid hybrids with unequal chromosome contributions from the original *S. officinarum* and *S. spontaneum* ancestors, and are likely to have more than ten copies of most chromosomes (Butterfield *et al.*, 2001). The complexity of the genotype means that sugarcane is not amenable to directed genetic manipulation through conventional breeding (e.g. by the formation of inbred lines), which influences the efficiency of variety improvement. Sugarcane breeding programmes worldwide generally follow extensive recurrent selection schemes, in which tens to hundreds of thousands of genotypes are tested each year in the hope of recovering superior individuals. The potential for molecular tools to improve breeding efficiency has long been recognised, and the South African sugar industry has been supporting research in this area since the early 1990s. This investment is beginning to have a direct impact in the SASEX breeding programme.

TOWARDS ANTIBIOTIC RESISTANCE-FREE TRANSGENIC SUGARCANE

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Abstract

The sugarcane transformation programme at SASEX depends on the use of a negative selection gene, which confers resistance to the antibiotic geneticin. Expression of this antibiotic resistance gene results in the selective development of transgenic cells on a medium containing the antibiotic, which is lethal to the untransformed cells (negative selection). The presence of the resistance gene is superfluous and undesirable once the transgenic plant has been produced, and its elimination is a priority for the future release of commercially acceptable genetically modified sugarcane plants. Alternatively, a positive selection gene such as the *manA* gene that encodes the enzyme phosphomannose isomerase (PMI) can be employed. When expressed, the *manA* gene confers a metabolic advantage on the transgenic cells, enabling them to grow on a mannose-containing medium. Initial results indicated that a mixture of mannose and sucrose is needed to support callus growth. MS medium supplemented with 5 g/L mannose and 10 g/L sucrose was shown to prevent growth of untransformed sugarcane cells and was subsequently tested for the selection of sugarcane calli transformed with the *manA* gene. Putative transformants have been regenerated from the mannose selection regime tested, namely 5 g/L mannose in combination with either 5 or 10 g/L sucrose.

USE OF MOLECULAR BIOLOGICAL METHODS TO IDENTIFY PLANT PARASITIC NEMATODES ASSOCIATED WITH SUGARCANE IN SOUTH AFRICA

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Abstract

Plant parasitic nematode genera commonly found associated with sugarcane were collected from trial sites in various regions of the sugar industry. Nucleic acids were extracted and the rDNA internal transcribed spacer 1 (ITS1) region amplified. Identification of the important genera was possible by size differentiation of the amplification products. Sequencing of the ITS1 region was used to confirm the identity of the isolates, by comparison with sequences in GenBank.

CURRENT STATUS OF RESEARCH ON SUGARCANE YELLOW LEAF SYNDROME IN SOUTHERN AFRICA

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Abstract

In the 1960s, yellowing symptoms in sugarcane were seen throughout East Africa. This was called 'yellow-wilt', a condition first described in Tanzania in 1962. The symptoms appear identical to those of Yellow Leaf Syndrome (YLS). In South Africa symptoms of YLS were first observed in 1994 and were conspicuous in varieties CP66/1043, N22 and N26, intermediate in N27 and less conspicuous in NCo376 and N14. Elsewhere symptoms have been linked to the presence of sugarcane yellows phytoplasma (SCYP) and/or sugarcane yellow leaf virus (SCYLV). However, in many instances symptoms are not accompanied by either pathogen. SCYLV was first detected in South Africa in 1997. At that time the virus was largely restricted to the northern regions, being found in some commercial varieties and certain genotypes undergoing selection in Pongola. The source of infection was thought to be varieties imported from the USA, Mauritius or Zimbabwe during the late 1980s. More recently the disease has spread to the south, but is still more prevalent in the northern irrigated areas. A survey of the industry revealed that more than two thirds of varieties grown in the north are infected with SCYLV, and approximately a quarter of varieties grown in the southern areas are infected. While other countries have reported significant yield loss in SCYLV infected cane, the effect of the virus, and of the phytoplasma, on South African varieties is not yet known with certainty. In this communication we discuss advances in the detection of both pathogens, tissue culture for the 'curing' of infected material and 'circumstantial' evidence indicating that yield loss does occur in South African varieties.

RATOON STUNTING DISEASE REDUCES CANE AND SUGAR YIELDS OF FIVE COMMERCIAL VARIETIES GROWN IN THE SOUTH-EAST LOWVELD OF ZIMBABWE

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Abstract

In 1998, sugarcane varieties NCo376, N14 and CP72-1312 were planted in one trial, and in 2000 varieties ZN1L and ZN2E were planted in a further trial to assess the cane and sugar yields of the five commercial varieties after artificial inoculation with *Leifsonia xyli* subsp. *xyli*, the bacterium that causes ratoon stunting disease (RSD). After artificial inoculation, stalk infection levels in the plant crops were N14 100%, NCo376 70%, CP72-1312 60%, ZN1L 50% and ZN2E 80%. In the 1998 trial, the average reduction in cane yield attributed to RSD from the plant crop through to the fourth ratoon of NCo376, N14 and CP72-1312 ranged from 13.2 to 20.7 t/ha. Corresponding losses in sugar yield ranged from 1.78 to 3.44 t/ha. In the 2000 trial, reduction in cane yield for ZN1L and ZN2E ranged from 21.7 to 39.7 t/ha, and in sugar yield from 2.4 to 5.1 t/ha. RSD did not significantly affect ERC % cane in all the crop cycles except in 2000, when RSD-free crops had 5% higher ERC % cane. On average, RSD reduced sugar yields by 18% in N14 and by 16% in CP72-1312, although there was variability between crop cycles. Yield reductions were attributed to shorter and in some instances thinner stalks, and not number of stalks. Smut levels in ratoon crops of NCo376 that had not been inoculated with RSD were very high and were more than treble those in inoculated treatments. Smut counts in uninoculated N14, CP72-1312, ZN1L and ZN2E were also higher than in inoculated plots, but the disease pressure was low in both treatments.

ISOLATION AND CHARACTERISATION OF SOME ENDOPHYTIC BACTERIA FROM PAPUA NEW GUINEA SUGARCANE

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Abstract

Endophytic bacteria were isolated from the stalks of sugarcane, *Saccharum officinarum*, growing in Papua New Guinea. Endophytic bacterial communities from extracted juice averaged 6×10^4 cfu/ml, which is 25 times greater than the number of endophytic bacteria found in commercial varieties in South Africa. Sixty isolates, representing the different colony morphology types, were used for *in vitro* inhibition tests against *Clavibacter michiganensis* subsp. *insidiosus* (a relative of the causative agent of ratoon stunting disease), *Fusarium napiforme*, *F. proliferatum* and *Ustilago scitaminea* (smut). None of the isolates showed inhibition of *Fusarium*. Thirteen belonged to the genus *Burkholderia*, as shown by 16S sequencing; among these, four inhibited the growth of *Ustilago scitaminea* and seven inhibited the growth of *Clavibacter michiganensis*. Six of the *Burkholderia* isolates showed strong chitinase activity.

FINANCING, VIABILITY AND COSTS ASSOCIATED WITH TRANSFERRING SUGARCANE LAND TO PREVIOUSLY DISADVANTAGED INDIVIDUALS

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Abstract

Natal Trust Farms (Pty) Ltd, a parastatal company, was contracted by the State to farm 2000 hectares of land under sugarcane, delivering the cane to Amatikulu mill. In 2001, the National Minister of Agriculture decided that all such parastatal companies would be dissolved so that the land could be sold to previously disadvantaged individuals, as part of the Land Reform programme.

Tongaat-Hulett Sugar Ltd (T-HS) was requested to assist with the transition and transformation involved in this process. T-HS proposed a contract farming service for one year, while at the same time providing a Design Agent function to transform the land into viable economic units. The Design Agent function involved creating the new farms and transforming the individual farms into cycle. This entailed compiling comprehensive business plans, the planning of shared mechanisation systems for economies of scale, the provision of property administration and conveyancing services and assisting with the selection, mentorship and training of the new farmers after occupation.

This paper focuses on the viability studies used to determine the optimal number of farms and the process of equalisation of risk and profit across all the farms. The problem of financing the purchase of the farms with limited owner capital and high debt levels was also investigated. This approach resulted in a 'capital sacrifice' by the seller to obtain an affordable value for the buyers. The costs involved in transforming and transferring the farms to new freehold cane growers were also quantified.

It is concluded that farm values, operating costs and the lack of own contributions to capital will continue to hinder successful Land Reform that is aimed at creating successful commercial farmers.

FACTORS AFFECTING THE ECONOMICS OF TRASHING

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Abstract

The trashing versus burning debate has been raging for many years, where trashing is defined as the physical separation of leaf material from the cane 'stick' prior to transporting the cane stick to the mill. This paper steers away from the environmental debate and focuses on the economics of trashing versus burning. Trashed cane can generally be supplied quicker than burnt cane, reducing sucrose deterioration and improving cane quality. A reasonable trash blanket left in the field after trashing inhibits weeds, thereby reducing herbicide costs. The additional organic matter above and below the soil surface improves moisture retention and soil health, which can significantly improve cane yields and profits. Trashing, however, is not appropriate in wet, low lying and cooler areas because the trash blanket increases the risk of stools rotting and inhibits ratooning respectively. The volume of trashed cane is also higher than burnt cane, which increases transport costs. In addition, extra trash delivered to the mill may necessitate upgrading the mill's processing facilities. In November 2002, a multi-disciplinary working group was set up to compile an appropriate spreadsheet model. The results to date support *a priori* expectations that, although trashing should be promoted under certain conditions in the South African sugar industry, further research is required in the following areas: (i) yield benefits of trashing under different circumstances, (ii) cane composition of different varieties, (iii) rates of cane deterioration, (iv) influence of density on transport costs, (v) labour productivity under different trashing regimes, (vi) the costs associated with alleviating bottlenecks at the sugar mills should trashing be widely adopted, (vii) the temperature effect in higher altitude areas, and (viii) the economics of trashed cane under irrigation.

SMALL-SCALE SUGARCANE CONTRACTOR ATTRIBUTES AFFECTING THEIR SERVICE QUALITY IN KWAZULU-NATAL

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Abstract

This study focuses on the attributes of small-scale sugarcane contractors that affect their quality of service as perceived by small-scale sugarcane growers (SSGs). Interviews were conducted with 114 randomly selected contractors from 10 mill group areas in KwaZulu-Natal between September 2002 and July 2003. Further interviews were conducted with SSGs for information on contractor service quality (timeliness of transport and general service, meeting of daily ratable delivery requirements, low downtime, good staff management, and minimal disagreements over service terms). Study results show that factors affecting a contractor's perceived service quality include gender, training, the quality of information used (industry-focused information sources such as the South African Sugar Association Experiment Station (SASEX) and the Ingede, or general sources such as radio broadcasts), and sugarcane tonnage transported (size of business). Being a male contractor and having a larger business positively influence service ratings as perceived by SSGs. The importance of the quality of information used and increased training levels highlight the need for the continual provision of relevant information and training for sugarcane contractors by extension services (government, SASEX, milling companies).

INSTITUTIONAL AND RESOURCE CONSTRAINTS THAT AFFECT SMALL-SCALE SUGARCANE CONTRACTOR PERFORMANCE IN KWAZULU-NATAL

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Abstract

This study aims to identify constraints that inhibit the performance (such as timely haulage operations, cost effectiveness) of sugarcane contractors in the small-scale sugar industry in KwaZulu-Natal (KZN). Information is drawn from both a sample survey, conducted with 124 randomly selected contractors from 11 mill group areas, and case studies (concerning institutional issues such as organisational structures) of contractors, sub-committee members and development officers, conducted in eight mill group areas of KZN between September 2002 and February 2004. Sample statistics and case study results show that contractors face institutional constraints (work allocation limitations, lack of performance incentives and high transaction costs, such as negotiation costs, the risk of a loss in work and contract default risk), cash flow problems, poor physical infrastructure and a lack of labour. It is concluded that the promotion of a more competitive small-scale sugarcane contractor sector will alleviate many of the problems (such as work allocation limitations) faced by small-scale contractors, while providing incentives for the provision of higher quality and cheaper services to small-scale sugarcane growers. Government has a role in strategising the creation of land markets and providing improved rural infrastructure (district roads). Government also needs to ensure unbiased tribal court rulings, review the impacts of minimum wage legislation on contractors sourcing labour, and provide protection for those competing for work.

SURVEY OF IRRIGATION SCHEDULING PRACTICES IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

Effective irrigation scheduling is a prerequisite to optimising the use of expensive irrigation water for sugarcane production in South Africa. Accurate irrigation scheduling is not widely practised in the sugar industry despite the many scheduling tools available to sugarcane growers. This leads to very low water use efficiencies (WUE) of approximately 50% of what could be achieved theoretically (Olivier and Singels, 2003). Irrigation scheduling can be defined as a programme of irrigation determining the amount of water and timing of application. Schedules can be classified as fixed (amount and cycle fixed for entire growing season), semi-fixed (amount and cycle are changed a few times to accommodate rainfall and significant seasonal and crop age induced changes in water demand) or flexible (amount and cycle are changed daily or weekly according to calculated water budget based on recent crop and weather conditions). Scheduling methods aim to maintain the soil water content in the optimal range by direct monitoring of soil water content or by estimating the soil water content through water budgeting.

The objectives of this study were to determine (i) which irrigation scheduling methods and tools are being used within the industry and to what extent, (ii) reasons for adoption or non-adoption of specific scheduling methods and (iii) practical limitations that prevent the successful implementation of scheduling techniques. The information will be used to identify priorities for future research and technology transfer to improve irrigation water use efficiency.

FRACTIONAL WATER ALLOCATION AND CAPACITY SHARING/WATER BANKING

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Abstract

In this paper, it is contended that the institutional arrangements and business models for water allocation, licensing and management have an overriding impact on how efficiently and effectively water is used in irrigated agriculture. Traditional methods for allocating and managing water are often based on volume per unit time water allocations, issued at some estimated level of assurance and managed using priority-based reservoir and river operating rules. This traditional approach is shown to have significant disadvantages in terms of ease of management, equitability and potential for fomenting conflicts. It also provides little opportunity for stakeholders to manage their water supply status and so have a positive incentive to use water efficiently. In contrast, fractional allocation and capacity sharing (FWACS) or water banking, which has been successfully implemented in the Mazowe catchment in Zimbabwe, is shown to enable more efficient, equitable and productive water use and management. FWACS is also reported to be a feasible and transparent management option for managing the reserve.

CANE AND ERC YIELDS OF TEN SUGARCANE VARIETIES IRRIGATED BY SUBSURFACE DRIP AT THE ZIMBABWE SUGAR ASSOCIATION EXPERIMENT STATION

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Abstract

In 1995, when drip irrigation was introduced into the Zimbabwe sugar industry, there were no guidelines on layouts of drip systems. An experiment was thus set up to assess cane and sugar yields and longevity of 10 sugarcane varieties that were planted using the standard and tramline layouts and irrigated by subsurface drip. In the standard layout, cane rows were spaced 1.5 m apart, and each cane row had a drip tape below. In the tramline layout, the drip tape was placed between two cane rows that were 0.42 m apart. The drip tape was laid out at 1.8 m apart. Cane and sugar yields differed between varieties and ratoons. There was a general decline in stalk populations in all varieties. Stool mortality was high in most varieties, while NCo376, ZN3L, ZN8 and N14 had a normal decline in stalk population. In the standard layout ERC % cane and cane yield were higher than in the tramline layout. Gross sugar yield was considered in a cost-to-benefit analysis that showed that ZN8 in the standard layout and N14 in the tramline layout were the most economic to grow using subsurface drip in Zimbabwe.

BENEFITS FROM PERFORMING IRRIGATION SYSTEM EVALUATIONS

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Abstract

In this paper the potential benefits of irrigation system evaluations are explored through the analysis of results from a case study. The effects of application depth, operating pressure, distribution uniformity and scheduling technique were evaluated using the *ZIMsched 2.0* irrigation systems and crop yield simulation model. Data measured from on-farm irrigation system evaluations performed in Pongola in 2001 and again in 2003, were used in *ZIMsched 2.0* to simulate sugarcane yield and water use for the period 1980 to 2000. The simulated crop yield and water use results facilitated a comparison of relative profit margins. The system performance, in terms of uniformity and application depth, was poorer in 2001 than in 2003, largely as the result of low system operating pressures in 2001. Results from the simulations show that with the scheduling practice followed by the farmer in 2001, these low system pressures resulted in reduced water applications. This in-turn resulted in reduced simulated sugarcane yields but an increase in irrigation efficiency, as there were fewer losses due to runoff and deep percolation. The calculated electricity and water costs were also lower in 2001 than in 2003. The system was upgraded in 2002 and the simulations undertaken using the 2003 system evaluation data showed increases in crop yield, water use and profitability, despite the accompanying increases in the calculated electricity and water costs. The improvement in the uniformity of the system from a DU_{lq} of 61% to a DU_{lq} of 68% had little effect on the simulated yields. For the case study, the greatest benefit of an irrigation system evaluation was that it provided information which facilitated making improvements to seasonal water applications. Based on simulated yields and water use, the impacts of these improvements on profitability ranged from R164 to R1882/ha.

SUGARCANE IRRIGATION SCHEDULING IN PONGOLA USING PRE-DETERMINED CYCLES

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Abstract

The aim of this study was to develop and evaluate simple to use irrigation scheduling guidelines for Pongola. The guidelines show recommended irrigation cycles for different months of the year, dependent on ratooning/cutting dates and type of irrigation system. The guidelines were developed using the CANESIM computer simulation model and long-term means of daily weather data. They include a simple method to adjust the irrigation cycle whenever it rains. To evaluate the guidelines, the CANESIM model was used to simulate crop yields and water use for crops cut from March to December using daily weather data for the period 1968 to 2001. The simulated crop yields and irrigation water applied, assuming irrigation water applications were scheduled using the cycle guidelines, were compared with the crop yields and irrigation water applied simulated if irrigation scheduling was based on the use of near-real-time daily weather data and the CANESIM computer simulation model. The index of agreement 'd' between the two sets of simulated sugarcane yields was 0.93, a value of 'd' equal to 1.0, indicating perfect agreement. The difference in the means of the two sets of simulated seasonal sugarcane yields was only 2%. The amounts of irrigation water applied were also similar. The increase in profit margins using either the cycle guidelines or the CANESIM model for irrigation scheduling, compared with irrigation scheduling based on simple summer and winter cycles, as are often used in Pongola, ranged from approximately R1079 per hectare to as much as R3485 per hectare when an opportunity cost of water was considered.

PRELIMINARY OBSERVATIONS ON THE IMPACT OF WHITEGRUB ON SUGARCANE YIELDS IN THE MIDLANDS NORTH REGION OF THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

During 1995 to 2001, two research trials and two farms in the Midlands region of the industry were monitored for yield effects attributable to whitegrub (various species of Scarabaeoidea). Although the trials were designed for other purposes, severe whitegrub infestations were observed in the soils on which the trials were situated, and the opportunity was taken to assess the impact of this soil pest on crop yield.

Results showed that there was an average reduction in yield (tons cane/ha) of between 55 and 23%, depending on variety and season. Such losses cannot be entirely explained by factors such as normal yield decline, and it is concluded that these losses may be ascribed to the activity of whitegrub.

THE EFFECT OF LIMING ON WHITEGRUB NUMBERS IN THE MIDLANDS AREA OF THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

It has been suggested that raising soil pH through liming could reduce the impact of whitegrub on crop yield in the treated soil. To test this hypothesis, whitegrub incidence was monitored in a trial designed to examine the effects of various lime treatments on crop yields of varieties N16 and N12.

Lime was applied at two rates (5 and 10 t/ha) and in combination with gypsum at 5 t/ha each. Results showed that, for N16, crop yield increased from 62 tons cane/ha (control) to 93 tons cane/ha (10 tons lime/ha treatment), and ERC increased from 6.4 to 10.8 tons sucrose/ha. Values for N12 were 85 tons cane/ha (control) to 87 tons cane/ha (10 tons lime/ha treatment). ERC increased from 10.3 to 11.5 tons sucrose/ha.

The aluminium saturation index (a measure of the impact of liming on soil pH) declined from 80% (control) to 20% (10 tons lime/ha treatment). However, no significant decrease or increase in white grubs numbers was recorded from any of the treatments. In the control plots, mean counts of 21.2 grubs per sample were recorded, while counts of 18.8 grubs were recorded in the highest lime treatment (LSD 8.9).

These results show that, although crop yields responded positively to the lime treatments, there was no clear association between the lime treatments and the number of whitegrub recovered. It is concluded that liming has no significant effect on the incidence of whitegrub.

TRAPPING *CHILO SACCHARIPHAGUS* (LEPIDOPTERA: CRAMBIDAE) IN SUGARCANE USING SYNTHETIC PHEROMONES

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Abstract

In June 2002, pheromone-trapping techniques were used successfully to detect the presence of *Chilo sacchariphagus* Bojer (Lepidoptera: Crambidae) in sugarcane at Mafambisse and Marromeu sugar estates in Mozambique. Trap design, bait concentration, trap placement and moth flight activity were examined. A simple trap constructed from a 2-litre plastic bottle and baited with two commercial synthetic sex pheromone vials (1 mg each) attracted and retained males. In mature sugarcane individuals were caught mostly at 2 m above ground. In the first experiment at Mafambisse, trap efficiency was the highest at 58%. The highest overnight catch in a single trap was nine males. Positive attributes of pheromone trapping as a monitoring tool are low cost, ease of operation, sensitivity at low population levels, and selectivity that negates the need for sorting.

Pheromone trapping was used as a complement to field scouting to determine the distribution of *C. sacchariphagus* in Mozambique on two other estates situated in the south of Mozambique. Moths were not detected. The pheromone-based trapping technique is being deployed in Malawi and South Africa as an early warning system for this pest. Additional uses include determining moth flight phenology and to examine the relationship between catches and infestation levels. Such knowledge would determine the period and intensity of moth attacks, and would help decide which and when control strategies are warranted.

RESISTANCE OF SOUTHERN AFRICAN VARIETIES OF SUGARCANE TO *CHILO SACCHARIPHAGUS* (LEPIDOPTERA: CRAMBIDAE) IN MOZAMBIQUE, AND DEVELOPMENT OF A NON-DESTRUCTIVE FIELD RESISTANCE RATING SYSTEM

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Abstract

While completing pre- and post-release surveys of sugarcane fields for release of the pupal parasitoid *Xanthopimpla stemmator* against *Chilo sacchariphagus* in Mozambique, it was noticed that there were differences in infestation levels in similarly aged varieties of sugarcane at Açucareira de Mozambique and Companhia de Sena sugar estates. Both these estates had recently imported numerous South African varieties of sugarcane. It was also noticed that the intensity of infestation of some of these varieties by *C. sacchariphagus* was different to the intensity of infestation of the same varieties by *Eldana saccharina* under South African conditions. These differences are discussed.

In addition, a difference between varieties was also noted in the degree of damage to the top leaves of different varieties of young sugarcane by early instar *C. sacchariphagus*. This led to the development of a promising non-destructive method of evaluating the resistance of these varieties against this borer. Comparison of the non-destructive method with the destructive stalk dissection methods showed some correlation. The method and correlations are described.

RESISTANCE MECHANISMS OF SOUTH AFRICAN SUGARCANE TO THE STALK BORER *ELDANA SACCHARINA* (LEPIDOPTERA: PYRALIDAE): A REVIEW

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Abstract

Despite plant resistance constituting one of the major defences of South African sugarcane against the stalk borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (Leslie and Keeping, 1996; Keeping, 1999; Keeping and Govender, 2002), little has been published regarding the mechanisms upon which this resistance is based. This paper reviews published and unpublished information on this subject, in an attempt to synthesise our understanding of the major resistance mechanisms against *E. saccharina*.

QUANTIFYING THE EFFECT OF SOIL SALINITY ON THE PHYSIOLOGY OF THREE SOUTH AFRICAN SUGARCANE VARIETIES

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Abstract

Salinity is of significant economic importance in the sugar industry because it affects the growth rate and sucrose yield of sugarcane. The aims of this study were to assess how various aspects of the physiology of sugarcane are affected by increasing levels of soil salinity during the growing season, and to determine whether or not there are differences in the physiological responses of different varieties to saline conditions.

The trial focused solely on salinity, with the cations Ca^{2+} and Mg^{2+} (predominantly as chlorides) as the dominant salts, and excluded the effects of Na^+ and sodicity as a variable, when assessing the effect of high electrical conductivity (EC) (ranging from about 100 to 800 mS/m) on the physiology and yield of varieties N17, N22 and NCo376. Investigations were carried out to assess leaf water potential, stomatal conductance and light-saturated rate of photosynthesis of these varieties under the experimental conditions provided.

It was evident throughout the trial that high levels of salt adversely affected growth for all three varieties; total above-ground biomass decreased significantly with increasing salinity. Although sucrose yields (tons/ha) of all three varieties showed a trend of decline with increasing salinity, only NCo376 showed significant treatment effects. Leaf water potentials at both pre-dawn and midday were found to be lower as EC increased, implying a mild water stress. N17 and NCo376 showed moderate sensitivity to salt because their responses to salinity, although variable depending on the parameter being assessed, were never as severe as the response of N22, which displayed more pronounced reactions at higher levels of salinity.

COMPOSITION OF THE SOIL MICROBIAL COMMUNITY UNDER SUGARCANE PRODUCTION AS INDICATED BY PHOSPHOLIPID FATTY ACID ANALYSIS

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Abstract

Phospholipid fatty acid (PLFA) analysis was used to characterise the microbial communities in the soil under long-term pre-harvest burning of sugarcane and several other land uses, and on a long-term experiment comparing sugarcane burnt before harvest and sugarcane harvested green with retention of a trash blanket. Trends in total PLFAs (total microbial biomass) followed the order: kikuyu pasture > native grassland > ryegrass pasture > maize > burnt sugarcane, and were higher under trashed than burnt sugarcane. Principal component analysis (PCA) of PLFA data revealed considerable differences with respect to PLFA composition in response to land use and trash management, suggesting substantial differences in microbial community structure. In both the comparison of land uses and the trash management trial, soil organic C content was significantly correlated with PC1, suggesting that changes in soil organic matter content can greatly affect soil microbial diversity. Among the land uses, burnt sugarcane had the lowest values for PLFA richness and Shannon's diversity index (indicators of microbial diversity) and conversion to green cane harvesting resulted in an increase in these values. The ratio of 18:2T₆ fungal fatty acid: bacterial fatty acids was highest under improved pastures. The ratio of ester-linked monosaturated fatty acids : ester-linked saturated fatty acids was increased in land uses with a high organic matter content, suggesting an increase in the ratio of Gram-negative: Gram-positive bacteria in response to greater substrate availability. It was concluded that sugarcane production under pre-harvest burning is particularly detrimental to the structural diversity of soil microbial communities and that the conversion to green cane harvesting with trash retention increases soil microbial diversity.

EFFECT OF MYCORRHIZA ON THE NUTRIENT UPTAKE OF SUGARCANE

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Abstract

Vesicular arbuscular mycorrhizae (VAM) fungi commonly infect plant roots, forming beneficial symbiotic relationships. The primary benefits of VAM plants are the enhanced acquisition and recycling of nutrients, particularly P, as well as soil moisture. This study compared the relationship between soil and leaf chemical elements of sugarcane variety N12 with low and high % mycorrhization (%myc). Seventy-one soil and leaf samples were selected from a 4000 m² area in a field of ratoon cane on a sandy soil on the KwaZulu-Natal north coast, and were analysed for major plant available nutrients by the Fertiliser Advisory Service laboratory of the South African Sugar Association Experiment Station. Percentage mycorrhization was determined using the Gridline Intersect method. Data from the soil and leaf analyses were divided into two categories: those from plots with low %myc (9-26%) and those from plots with high %myc (32-53%). Relationships between soil and leaf factors were then determined using multivariate analysis (ADE-4 software). Results from high %myc plants indicated enhanced relationships between soil pH and leaf Ca, soil pH and leaf N, soil Ca/Mg and leaf N, and soil Na and leaf K while the relationship between Mg/Ca and leaf K was depressed in high %myc plants. Ca exists in the middle lamella as calcium-pectate, which helps with resistance to fungal infection. Nitrogen and Mg are required for photosynthesis, while Na may increase stomatal regulation under water limiting conditions. VAM colonisation therefore, may play a role in plant physiology in terms of resistance to bacterial and fungal pathogens, increased photosynthetic rates and enhanced stomatal regulation under water stressed conditions.

ASH AND SUGARS IN CANE JUICE AT NCHALO SUGAR ESTATE, MALAWI: RELATIONSHIP WITH INORGANIC CONSTITUENTS IN SOIL

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Abstract

Nchalo Sugar Estate in Malawi has consistently higher molasses purities and usually higher ash in final molasses than other mills in southern Africa. An investigation was conducted over two seasons to determine the main constituents of the ash and what relationship existed between the ions in juice, juice quality and the soil cations and salinity parameters. The influence of time of harvest was also considered.

Juice potassium, sulphate and chloride ions were the main components of ash. Soil potassium in the upper 60 cm of the soil profile correlated with the ash and potassium content of the juice extracts. Calcium and magnesium in the soil were positively associated with sucrose. Calcium and sodium in the soil were significantly and positively correlated with their respective cations in juice. The influence of time of harvest on soil constituents sampled within the 0-30 cm soil layer was non-significant except for electrical conductivity.

THE SASEX FERTILISER ADVISORY SERVICE: A REVIEW OF 50 YEARS OF SERVICE TO THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

This year, the Experiment Station's Fertiliser Advisory Service (FAS) enters its 50th year of service to the industry. Since it was commissioned in 1954, FAS has achieved recognition as one of the leading agricultural laboratories, not only in South Africa, but also in other cane producing countries. The laboratory provides an efficient and reliable service to growers and research workers, giving cost effective, environmentally friendly fertiliser recommendations based on soil and leaf analysis. It also analyses organic manures and gives advice on water and effluent for irrigation, while keeping pace with advances in modern analytical techniques and instrumentation.

This paper reviews the historical development of FAS since 1954, and highlights technical achievements in terms of the selection and calibration of appropriate soil and leaf testing methods for determining nutrient requirements, advances in the automation of laboratory instrumentation, and the development of soil-specific fertiliser recommendations, nutrient retrieval systems and computer aided decision support programs for more effective fertiliser management. The impact of new challenges from precision agriculture and the rapidly growing soil sustainability school on soil health evaluation and soil management are considered.

COST IMPLICATIONS AND GROWER PERCEPTIONS OF PHOSPHORUS FERTILISER RECOMMENDATIONS BASED ON SOIL TESTS NOT CALIBRATED FOR SUGARCANE

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Abstract

Input costs for sugarcane production have escalated sharply over the past five years, especially fertiliser costs. It has become imperative for growers to manage fertiliser input costs by ensuring that they have an accurate nutrition management programme in place. The South African Sugar Association Experiment Station has, over many years, contributed hugely through their research and extension departments to developing standard methods of soil analysis and critical soil norms for making cost effective fertiliser recommendations for sugarcane. The leading role that the Fertiliser Advisory Service (FAS) has played in this regard is widely acknowledged, both locally and internationally. However, in recent years growers in the north have made increasing use of laboratories where the soil tests have not been calibrated for sugarcane. This has led to diverse fertiliser recommendations and to considerable confusion among growers, as the recommendations call for excess application of phosphorus (P) and potassium (K) fertilisers in particular. This is not in the best interests of growers, nor of the fertiliser and cane processing industries. The focus of this paper is to look at the implications of using P fertiliser recommendations that are based on different soil phosphate extraction procedures than those of FAS, and that are not calibrated for sugarcane production.

WHICH IS THE MOST IMPORTANT CROP WHEN ASSESSING NITROGEN APPLICATIONS – THE NEXT OR THE LAST?

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Abstract

A review of nitrogen (N) fertiliser management in the Australian sugar industry was undertaken to identify new strategies to improve N fertiliser use efficiency and to fill gaps in knowledge relevant to N fertiliser management. The Australian sugar industry has a history of high N fertiliser usage, with applications increasing from the 1960s to the late 1990s. However, industry average sugarcane production has not kept pace with N fertiliser applications, resulting in a steady increase in N fertiliser applied per ton of sugarcane harvested.

Historical and recently developed N management strategies rely on matching N applications to the predicted/expected yield of the forthcoming crop. High applications of N fertiliser by farmers are a rational reaction to (i) the uncertainty of these predictions/expectations, and (ii) the yield reductions caused by long-term under-fertilising with N. While **sustained** under-application of N undoubtedly reduces cane yields, there is considerable evidence in the Australian industry that greatly reducing N fertiliser applications for a **single** crop does not significantly reduce sugarcane production.

Consequently, a new philosophy of N fertiliser management can be envisaged, that removes the uncertainty driving farmers' decisions to over-apply N. Rather than aiming at fertilising the coming crop, one could aim at replacing the amount of N lost from the previous crop, the majority of which is in harvested cane and can be easily estimated. To better examine this new 'replacement' N management strategy, long-term simulations were undertaken of sugarcane production in four regions in Australia and one in South Africa. The replacement strategy had similar productivity, greater profitability and lower environmental N losses than conventional N fertiliser management. The choice of soils and the inclusion of a South African climate in the simulations ensured that the results are biophysically relevant to the South African industry. However, before this system can be considered as a practical N fertiliser management system in any country, it needs extensive field testing. A testing programme is commencing in Australia.

CHANGING FERTILISER PRACTICES IN THE SMALL-SCALE SECTOR OF THE SOUTH AFRICAN SUGAR INDUSTRY: THE ROLE OF EXTENSION

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Abstract

Since 1980, sugarcane production by small-scale growers (SSGs) has increased significantly, and today comprises about 15% of the annual crop in South Africa. Opportunities exist for increasing sugarcane production in the SSG sector through both vertical and horizontal expansion. This paper focuses on current practices with respect to low fertiliser usage in the small-scale sector, the potential for vertical expansion through nutrient replenishment, and the beneficial role that extension can play in achieving this.

Sugarcane crops grown by SSGs in South Africa are generally produced on soils where the levels of nutrients have been depleted, which is in contrast with the soils of large-scale (commercial) farmers, where regular fertiliser application is an accepted management practice. An assessment of records from the Fertiliser Advisory Service of the South African Sugar Association Experiment Station showed that a high proportion (46%) of SSG soil samples are strongly acid ($\text{pH} < 5$) and severely deficient in plant available phosphorus, probably because of the high cost of replenishing phosphoric fertilisers. The reasons for a practice that is effectively 'soil nutrient mining' by SSGs are explored, and a practical solution to benchmarking and mapping soils for a 'best fit' replenishment practice is proposed in the development of a practical tool that can be used in the field by the Extension Officer to circumvent the need for frequent soil analyses in the future.

DRI - WHAT IS IT?

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Abstract

For many years, the preparation of cane has been measured in terms of the ratio of brix in open cells in prepared cane to the total brix in an equivalent sample. The process involves gently washing a fixed mass of sample in a fixed mass of water for a specified time. A second sample is prepared further in a cold digester. The preparation is expressed as the ratio of the brix washed from the prepared cane to the total brix in the sample from the cold digester as a quantity known as preparation index or PI. Although theoretically sound, the process has some practical difficulties, which can cause large errors in the values reported. The causes of these errors include effects such as the washing time and temperature of the water. This, together with the time taken to measure a single sample, has led to the method falling into disfavour.

This paper describes an alternative method of expressing preparation as a function of how easily the brix can be extracted from the open cells rather than the fraction of open cells. The concept uses the theory of mass transfer and diffusion through concentration gradients to define the quantity, which has been called the 'diffusion rate index' or DRI. DRI is the time constant associated with the process of washing the brix out of a particular preparation.

A machine incorporating the theory and several practical innovations has been designed and manufactured. The main focus has been on automation and reducing the inputs required from the operator. Several of these machines have been installed in the South African industry. Some comparisons between DRI and the cane preparation are discussed.

FLOW METERS FOR DETERMINING MIXED JUICE MASS?

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Abstract

Accurate massing of mixed juice is critical to the South African industry for cane payment purposes, as well as for controlling performance in a factory. The batch weighing system usually employed in the South African sugar industry consists of load cells, holding tanks, weighing bins, processors, valves and actuators. Due to the nature of the mechanism used, the system can be subject to frequent downtime because of mechanical and electronic malfunctions. Any errors or interruptions within the weighing system could result in mixed juice weighing being suspended or the mill stopping until the problem is rectified. During these periods, the unweighed mixed juice has to be estimated as accurately as possible.

The Cane Testing Service (CTS) has developed a number of methods for estimating the mass of mixed juice in such an event (Brokensha, 1997). These methods usually involve the use of an assumed pol factor, the value of which may differ according to the amount of cane already crushed in the week. Due to the indirect nature of such a correction, and the need for decision making at laboratory manager level, the correction of the mixed juice mass can be lengthy and disputes as to its validity can arise.

With a view to the eventual standardising on a direct method that could be applied automatically in all situations, the determination of mixed juice tonnage by flow meter was investigated at the Umzimkulu mill.

The daily tonnages of mixed juice derived via the use of a flow meter already existing at the mill were compared against the routine massing of mixed juice and were recorded over the 2003 crushing season. After correcting the volumetric flow meter values for temperature, brix and specific gravity, the data showed a very good correlation to the tonnage obtained by the conventional massing of mixed juice.

This paper describes the two measuring systems and discusses the preliminary results.

MILL-WIDE WATER MANAGEMENT IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

Increasingly stringent environmental constraints, as outlined in South African water and environmental law, require industry to improve water management in a sustainable and equitable manner. There are opportunities to review water utilisation, re-use and discharge.

In this paper the past and present trends in management practices and technology applicable to water utilisation in South African sugar mills are briefly summarised. Technologies to enable higher levels of water recovery and re-use are reviewed in terms of their current and future application in the sugar processing cycle. The important aspects mills should consider when evaluating the impact, benefits and costs of alternative technologies are discussed.

STARCH HYDROLYSIS USING (α -AMYLASE: A LABORATORY EVALUATION USING RESPONSE SURFACE METHODOLOGY

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Abstract

The South African cane sugar mills use a thermostable amylase enzyme (produced by genetically modified strains of *Bacillus licheniformis*) to control seasonally high starch levels in juice. The recommended point of application of the enzyme is the third or fourth evaporator effect since the temperatures in these effects are high enough for the starch to remain solubilised, but low enough to prevent deactivation of the enzyme. The extended residence time and lower Brix in these effects are also believed to favour enzymatic action compared to conditions in the syrup tank.

While considerable effort has been made to characterize the effect of factory parameters on the previous generation of commercially available α -amylases when they were first introduced to the cane sugar industry, not much work has been done on the thermostable enzymes, thus spurring this investigation. The effects and interaction effects of temperature, Brix, pH, starch concentration and enzyme concentration on the amount of starch hydrolysed by the enzyme in a sucrose solution were determined using statistical experimental design techniques. Experiments were conducted as batch processes, while the stirring rate, calcium content and the volume of each run were kept constant.

A model was derived and corresponding response surface diagrams were used to identify trends in terms of the evaluated parameters. Some experiments were done to lend support to the model, which was shown to be a good predictive tool within the experimental domain investigated.

REMOVAL OF SUSPENDED SOLIDS FROM CLEAR JUICE BY DEEP BED FILTRATION

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Abstract

Clarification of mixed juice in South African sugar factories is currently done using the clarifiers only. The removal of suspended matter when using clarifiers alone is not always sufficient, hence there was a need to investigate a device such as the Deep Bed Filter, which maintains good juice quality during clarification problems. This piece of equipment uses the readily accessible filtration media - magnetite, anthracite and silica sand - which have been selected according to their physical properties. These media require only water for regeneration.

A small pilot-scale deep bed filter was tested at the Sugar Milling Research Institute to determine the feasibility of using such a device for filtering clear juice.

The results for two different media size sets are compared and discussed. The media size selection and the efficiency of the equipment are evaluated by assessing the solid retention capacity of the bed.

RAW SUGAR FILTERABILITY IMPROVEMENTS WITH SYRUP CLARIFICATION

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Abstract

A study has been initiated to review syrup clarification technology, with the objective of finding methods of improving syrup clarification, including chemical addition, and with special reference to aeration and flocculation problems. Preliminary results suggest that significant improvements to raw sugar quality are possible, particularly filterability. The review to-date is presented, with recommendations on future work.

HEAT AND MASS BALANCE USING CONSTRAINT EQUATIONS, A SPREADSHEET, AND THE NEWTON-RAPHSON TECHNIQUE

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Abstract

To work out a balance problem in a factory, two simple rules are applied. Firstly, a steady state condition applies. This gives rise to the second rule: what goes in must come out. Based on these rules, the equations for heat and mass balances can be derived. There are several packages available to solve these rules or constraints. The choices include Simulink and Sugars. The use of these packages would require the ownership of a software licence. Often it is not cost effective to purchase the licence for a single project. This leaves the choice of solving the problem using a spreadsheet.

Once the equations are expressed in terms of brix, fibre, etc, the equations become non-linear, and linear methods of solution such as Gauss-Jordan row reduction are no longer possible. Traditionally, the equations are then manipulated to isolate terms and thereby extract a solution. This approach fails when there are numerous return streams. In this case, the iteration facility of the spreadsheet is used in an attempt to resolve the values that could not be solved explicitly.

This paper describes a technique where the constraint equations are entered into the spreadsheet for each point of mixing or separation in the system. The Jacobian matrix can then be constructed using some elementary rules. Thereafter, the power of the spreadsheet matrix functions can be employed to iterate simply to a solution using the Newton-Raphson (or any other applicable) technique. This process eliminates the need to manipulate the constraints to isolate variables, and ensures that the iteration can be handled in an orderly manner.

OPTIMUM DISTRIBUTION OF HEATING SURFACE IN A MULTIPLE EFFECT EVAPORATOR TRAIN

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Abstract

The overall specific evaporation rate (in kg/h/m²) of a multiple effect evaporator train is highly dependent on the distribution of heating surface among the effects. Previous authors (Hugot; Buczolic and Zadori) have each given criteria for achieving optimum heating surface distributions. The criteria given by the above authors are different from each other, and while they get very close to an optimum distribution, better distributions can be achieved.

The present work uses a spreadsheet model of a multiple effect evaporator train and the optimising routines in the spreadsheet software to find the distribution of heating surface along the evaporator train which gives the highest specific evaporation rate. The vapour temperatures are the parameters that are varied in order to maximise the overall specific evaporation rate.

Similarities between the previous authors' criteria and the results of the spreadsheet optimisation are discussed.

EVALUATION OF THE SACCHAROFLEX 2000 REFLECTANCE MEASURING INSTRUMENT FOR REFINED SUGAR COLOUR ESTIMATION AT HULETTS REFINERY

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Abstract

Due to the successful use of the Saccharoflex 2000 reflectance measurement instrument on the estimation of refined sugar colour elsewhere in the world, it was decided by Tongaat-Hulett Sugar to evaluate the instrument at the refinery in Durban. Tests were carried out on first, second, third and fourth refined sugars, the results of which showed a good correlation between the ICUMSA colour measurement and the reflectance reading obtained from the Saccharoflex 2000. The instrument offers a number of advantages, the main one being that a refined sugar colour value can be obtained in less than a minute. The refinery has therefore purchased one for process control.

CAKING OF WHITE SUGAR AND HOW TO PREVENT IT

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Abstract

Water is a major constituent of food products even if it is present at a trace level as in white crystalline sugar. Molecular interactions between sugar and water are at the origin of structural as well as mechanical properties (density, compressibility, flow) of bulk sugar. Conditioning of white sugar is therefore difficult because it is sensitive to relative humidity and temperature of surrounding air.

Water activity of sugar crystals in storage cells should be equilibrated with surrounding air at a reasonable value if it is desired to obtain stability and free flow of bulk sugar. The period needed for such equilibration is called the ‘maturation’ or curing period. In order to understand the physico-chemical phenomena leading to caking we studied the effect of parameters such as equilibrium relative humidity (ERH), temperature, grain size distribution on the lumping of sugar crystals. Likewise the conditions of de-caking of ‘softly’ caked bulk white sugar were studied in a pilot silo.

During the 1999 and 2000 campaigns, white sugar freshly dried and not stabilised by maturation was sampled and tested in a pilot silo. The objective was to follow crystal lumping under a microscope camera and to measure shear stress while changing temperature and ERH conditions. In parallel, water vapour adsorption isotherms were established at different temperatures for sugar samples submitted to caking and de-caking conditions.

ANALYTICAL CHROMATOGRAPHIC SOLUTIONS FOR SUGAR PROCESSING

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Abstract

An overview is given of some of the varied chromatographic techniques which have been used in the South African sugar industry over the past 30 years. These include accurate, precise analytical procedures used for cane payment and factory control. Chromatographic procedures for estimating cane delays, troubleshooting for bacterial infection, factory corrosion and measuring inversion in evaporators are reported. Other applications include the determination of polysaccharides, anions and cations in factory products such as juices, molasses and VHP and white sugars.

APPLICATIONS FOR A NEW SUCROSE ANALYSER: PRELIMINARY FINDINGS

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Abstract

A Sucrose Analyser, developed by the Sugar Research Institute in Australia, was made available for evaluation in the South African sugar industry. The analyser was installed in line on evaporator syrup, at a raw sugar factory. After an original *in situ* calibration with sucrose solutions of known concentrations it performed satisfactorily and repeated calibrations showed no evidence of drift or bias. Tests were carried out for six weeks during which the sucrose values were logged by the factory data capturing system.

The Sucrose Analyser was then set up for laboratory applications at the Sugar Milling Research Institute (SMRI). Both continuous and batch operations were evaluated using juices, syrups and molasses with the appropriate calibrations. Again the analyser performed well. The paper describes how the analyser was calibrated and comments on the results obtained.

QUANTIFICATION OF CRYSTAL CONGLOMERATES USING IMAGE ANALYSIS

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Abstract

A regular crystal form, in particular the absence of conglomerates, is an important aspect of refined sugar quality because irregularities increase the quantity of mother liquor which remains on the surface of the crystals or is contained within occlusions in the crystals themselves. This aspect of sugar quality is of greater importance when processing lower purity liquors due to the increased impurity load of the mother liquor retained by the crystals in these circumstances.

The current technique for the quantification of conglomerates in sugar samples, namely the *crystal regularity index*, is based on the subjective classification of photographed crystals in terms of three or four groupings. Each of the groupings is given an arbitrary weighting in terms of crystal regularity and the total score for the sample is expressed as a percentage of the maximum score which could be obtained by a sample of crystals of perfectly regular shape. This technique is both slow and dependent on subjective classification by one or more observers.

An attempt has been made to develop an improved technique for conglomerate quantification, automating the procedure as far as possible and replacing the subjective element of the original analytical method by using computerised image analysis procedures. After the extensive investigation of a number of possible classification criteria, some preliminary methods have been obtained which are based on the analysis of crystal shape and the characteristics of the crystal edges.

USING THE BRIXIUS MODEL TO PREDICT TRACTION OF HEAVY SUGARCANE MACHINERY

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Abstract

From 1976 to 2003, 60% of sugarcane harvests in the north of Villa Clara in Cuba have been affected by heavy rainfalls, averaging 215 mm. Many interruptions to the harvesting operation have been caused by infield transport not being able to traverse the soft vertisol soils that prevail in this area. The Brixius model was used to predict the tractive performance of a New Holland 110-90 tractor with a cone index (CI) of less than 700 kPa.

The main ratios and forces that characterize traction dynamics (motion resistance, net traction, motion resistance ratio, gross traction ratio, net traction ratio and tractive efficiency) were obtained as a function of soil strength and dynamic wheel load. The results showed that the RA-6 trailer can only be pulled with a CI higher than 400 kPa, working on 22% wheel travel reduction (wheel slip).

WHITE CANEGRUBS: A POTENTIAL PEST CHALLENGE TO THE SUGAR INDUSTRY IN KENYA

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Abstract

Keya (1995) pointed out that Kenya is relatively free from most sugarcane diseases and pests. However, crop improvement programmes must take cognisance of sugarcane smut, mosaic, ratoon stunting disease and pests such as root feeders, shoot feeders, stem borers, leaf and stem feeders and animal pests.

Damage to the Australian sugarcane crop by insect and animal pests cost the industry more than \$20 million in 1996. The figure included the value of lost production and cost of pesticides. Reliance on pesticides had a negative impact on the environment and a good knowledge of the pest was also needed (Allsopp *et al.*, 1993).

In the year 2002, an unusual wilting and final death of crop on some 50 hectares was a very new experience in one of the outgrowers' sugarcane g zones of Nzoia sugar factory. Given the average cost of Ksh 32,410/=(USD 405) for the establishment of one hectare of cane, a loss of up to Ksh 1,620,500/=(USD 20,256) was incurred.

The implications of this damage to the crop could be far reaching to the entire sugar-growing scheme. An immediate step was taken to establish the cause of damage and it was established that white grubs of the *Lepidiota* species had infested the fields.

Various remedial measures including cultural and chemical control were adopted. Deep ploughing of the fields using the mouldboard completely eliminated the occurrence of the pest on the Nucleus Estates. Usage of Imidacloprid on the crop had a systemic action that killed the pest in the root zone as opposed to direct spraying. The use of Chlorpyrifos in the furrow and directly sprayed on the pest had good results.

FALLOWING AND GREEN MANURING PRACTICES FOR IRRIGATED SUGARCANE

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Abstract

There are at present concerns within the sugar industry that long-term monoculture has led to soil degradation and consequent yield decline (Meyer and van Antwerpen, 2001; Garside *et al.*, 2001).

Studies have previously been conducted to assess the effects of fallowing and green manuring on subsequent irrigated sugarcane yields:

- Comparison of commercial yields in Swaziland indicated a response to fallowing and green manuring of about 50% in the plant crop and 25% in the first and second ratoons, with no response thereafter (Nixon, 1992). However, this effect was shown to be partly caused by seasonal variations in yield due to time of harvest, as previously demonstrated by Sweet and Patel (1985).
- A further investigation was conducted to assess the effects of fallowing and green manuring practices over a seven-month period on sugarcane yields and the physical properties of a poorly draining clay soil (Nixon and Simmonds, 2004). There were yield increases of 10 and 8% in the subsequent plant and first ratoon crops respectively, after fallowing and green manuring, but no significant yield responses in the second ratoon. Topsoil air-filled porosity increased from 11% under continuous sugarcane to 16-19% after fallowing, and steady state ponded infiltration rates were increased from 0.6 to 1.3 mm/h. These improvements were no longer evident after a year back under sugarcane. Levels of soil organic matter were reduced in all cases, probably as a result of the tillage operations involved. In the plant and first ratoon crops, total root length was related to air-filled porosity, indicating the importance of below-ground air supply for sugarcane production on poorly draining soils.

The findings of these studies are consistent with those of other experiments conducted in Australia (Garside and Bell, 2001; Braunack *et al.*, 2003). Partly as a result of this work, fallowing and green manuring have now become standard practices at several sugar estates in Swaziland.

THE DEVELOPMENT OF AN AUTOMATED PITH-FIBRE SEPARATOR FOR THE CANE SUGAR INDUSTRY

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Abstract

The need to determine accurate pith-fibre ratios in cane prompted the design and development of a fully automated apparatus that separates pith, fibre and sand from a sample of shredded cane or bagasse. With the continuous introduction of new cane varieties into the sugar industry, a quick and simple method of categorising these components is useful as they impact on diffuser operations, e.g. percolation rates. The equipment has been tested on shredded cane and bagasse from various factories and on various cane varieties from the South African Sugar Association Experiment Station.

The results show that the apparatus gives excellent repeatability in terms of pith and fibre quantities for the same batch of sample. The poster describes the advantages of the new method over the old method of separation. Results include data and comments obtained from tests on 10 different cane varieties.

REMOVAL OF ASH: POTENTIAL USE OF ELECTRODIALYSIS

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Abstract

It is well known that ash adversely affects the sugar industry. Ash has been shown to reduce sucrose recovery, decrease crystal growth and contribute to scale formation on evaporators. Over the past few decades various techniques have been employed to remove ash from sugar solutions. More recently, electrodialysis has been investigated.

Within an electrodialysis unit, the solutions are separated by alternately arranged anion exchange membranes (permeable only for anions) and cation exchange membranes (permeable only for cations). The membranes are arranged parallel to one another to form an electrodialysis stack. When a potential is applied across the selectively permeable membrane stack, anions selectively move through the anion exchange membrane and cations selectively move through the cation exchange membrane. The transport of ions across the membranes results in ion depletion in some cells (de-ionized, diluent or desalinated stream), and ion concentration (salt concentrate) in alternate cells. Further transport of the ions to the next cell is stopped by the next membrane (Figure 1). The electrodialysis

process thus allows for the effective removal or concentration of ions (salts).

A BASIC METHOD FOR THE ANALYSIS OF STARCH IN CLEAR JUICE

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Abstract

The analysis of starch in factory streams and products is tedious and time consuming. It is not surprising, therefore, that only one South African sugar mill laboratory currently analyses the factory streams for seasonal starch levels and trends. This essentially means that high starch levels are picked up only in the final raw sugar, causing an uncomfortable delay between detection and application of starch hydrolysing enzymes to rectify the situation.

Various attempts have been made world-wide to simplify the analysis. It appears that most of these attempts have been based on the 'SASTA method' or the 'SASTA Simplified method'. The latter was further simplified by the Sugar Processing Research Institute (SPRI) in the United States of America, who developed the 'Rapid Starch Test'. Further modifications made at the Sugar Milling Research Institute, as well as the application of this method to clear juice to eliminate the centrifugation step, resulted in the 'Basic Starch Test', which is the subject of this poster. To render this method even more straightforward, a predetermined calibration graph was set up and distributed for use in a ring test between several South African sugar laboratories. Feedback on the method was positive, and results indicated that the method could be used with confidence, albeit using a much higher tolerance.

A NEW FILTRATION SYSTEM FOR GUM ANALYSIS IN RAW SUGAR AND MOLASSES

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Abstract

'Gums' are defined as a heterogeneous group of compounds that form a precipitate on addition of acidified alcohol. Starch and natural gums occur in undamaged sugarcane. Natural gums include hemicelluloses, pectins and dextrans. Bacteria also produce gums such as dextrans and levans, during and after the milling process (Jennings, 1964). These molecules are all soluble in water but insoluble in alcohol, providing an easy method of separation.

Increased health and environmental concerns have prompted an investigation into finding an alternative filtration system to asbestos in the gums method. In the Fibroxcel range of filter aids (AEB Africa), Fibroxcel 10, with a glass fibre pre-filter, displayed potential in reproducing results comparable with the asbestos filtration system, with the added benefit of being environmentally friendly and improving filtration time.

A ring test was conducted between four laboratories in the South African sugar industry and results confirmed reproducibility of the new method in raw sugar and molasses. A tolerance for gums in molasses has never existed and an intra-laboratory comparison conducted at the SMRI established a tolerance of ± 2000 ppm. The Factory Control Advisory Committee approved the revised methods for determination of gums in molasses and raw sugars on 10 March 2004.

THE DETECTION OF PROTEIN IN REFINED SUGAR

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Abstract

The sporadic appearance of floc, and more particularly acid beverage floc (ABF), in soft drinks is a source of concern to cane sugar refiners. Although floc is unsightly, it is a quality parameter that is unlikely to impact on the health and nutritional status of sugar. The refiner is often hastily blamed and compensation sought despite the fact that claims may not always be valid.

There is agreement among researchers that ABF in soft drinks arises from aggregation of macromolecules in the solution after acidification. This is believed to be initiated by a protein component that complexes with polysaccharides, giving rise to observable floc. Furthermore, it has been shown that a relationship exists between the protein concentration and the initiation of floc. Two rapid dye-binding techniques were therefore investigated for the detection and quantification of protein in refined sugar.

The Amido Black dye method involves staining a membrane after filtering the sugar solution to give a visual indication of floc positive sugar.

The Coomassie Blue protein assay method is a modification of the colorimetric Bradford protein dye-binding method in which absorbance is measured at a specific wavelength. A protein standard was used for the calibration graph.

Results to date indicate that the protein content of floc positive sugars ranges from 2 to 18 mg/kg. There are indications that the protein concentration correlates with the 10-day low Brix Coca-Cola test (Anon, 1998).

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