ISSCT AGRONOMY WORKSHOP
Réduit, Mauritius
21 - 25 July 2003

"Opportunities in sugar cane agronomy to confront the new realities emerging in the 21st century"

PROGRAMME
REPORT
ABSTRACTS

Tentative Programme

Sunday 20 July	**Afternoon** Registration Welcoming cocktail
Monday 21 July	**Morning** Inaugural ceremony Green cane harvesting and management of residues **Afternoon** Visit to the sugar cane industry
Tuesday 22 July	**Morning** Innovative approaches to nutrient management **Afternoon** New/improved practices to increase sugar and cane yields
Wednesday 23 July	Visit to the sugar cane industry
Thursday 24 July	**Morning** New/improved practices to increase cane biomass for production of sugar / other products. **Afternoon** Moving towards the delicate balance between sugar cane production, natural resource utilization, environmental impacts and economics
Friday 25 July	**Morning** Information Technology in agronomic practices. Concluding remarks **Afternoon** Free Farewell dinner (evening)

BACK

Report

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Abstract
This paper summarizes the activities of the International Society of Sugar Cane Technologists (ISSCT) Agronomy Workshop held 21 to 25 July 2003, at the Mauritius Sugar Industry Research Institute (MSIRI) in Réduit, Mauritius. Paper presentations were grouped under the general topic headings of: green-cane harvesting and management of residues; innovative approaches to nutrient management; new/improved practices to increase cane and sugar yields; new/improved practices to increase cane biomass for the production of sugar/other products; moving toward a delicate balance among sugarcane production, natural resources utilization, and environmental impacts and economics; and information technology in agronomic practices. Included in the 5-day workshop were field tours to view common agronomic practices in the Mauritian sugarcane industry. It was concluded that the continued elucidation of the sugarcane plant's response to nutrient levels, stress, and other variables and the integration of this knowledge with new electronic technologies to include their incorporation into decision support systems will result in input reductions and the sustained or higher sugar yields necessary to insure global profitability for the sugarcane industry in the 21st century.

Keywords: Crop modelling, decision support systems, environmental issues, green cane harvesting, nutrient management, plant modelling, and precision agriculture.

Introduction
The evolution of computer and satellite technologies and the increasing concerns about the environment and the struggle of the international cane sugar industry to remain profitable are creating tremendous opportunities for sugarcane agronomists. It is allowing them to incorporate or integrate old methodologies such as crop rotations and the recycling of crop residues and other green manure crops with new precision agriculture or site-specific application technologies as well as to predict the economic outcome of the adoption of these practices. Fruition of these efforts will lead to reduced inputs and higher crop yields, which will result in improved profitability for cane growers throughout the world.

The ISSCT Agronomy Workshop held 21 to 25 July 2003 at MSIRI was designed to address these challenges under the general theme of "Opportunities in Sugarcane Agronomy to Confront the New Realities Emerging in the 21st Century". The holding of the workshop at MSIRI had special significance as the workshop marked the beginning of the official celebration of MSIRI's 50th anniversary.

Workshop Sessions
The special significance of MSIRI's anniversary and the institute's hosting of the workshop was highlighted by an address to the participants during the opening ceremony by Mr K. A. Offmannn, GCSK, President of the Republic of Mauritius as well as addresses by Mr J. C. Hoareau, Chairman of the MSIRI Board, Dr L. J. C. Autrey, Chairman of the ISSCT Executive Council and Director of MSIRI, and the Honorable P. K. Jugnauth, Minister of Agriculture, Food and Technology Resources. The opening session concluded with an invitational address by Dr R. V. Rossel from the Australian Centre of Precision Agriculture. Dr Rossel's address was entitled: "20th Century Precision Agriculture for 21st Century Agriculture". Thirty-nine papers were presented during the workshop that had 81 registrants from 19 countries. Oral presentations were divided into the general topic areas of: green-cane harvesting and management of residues; innovative approaches to nutrient management; new/improved practices to increase cane and sugar yields; new/improved practices to increase cane biomass for the production of sugar/other products; moving toward a delicate balance among sugarcane production, natural resources utilization, and environmental impacts and economics; and information technology in agronomic practices and included a discussion period at the end of each session. This paper attempts to provide a general overview of the issues discussed by the presenters and participants during the sessions.

Green Cane Harvesting and Management of Residues.
Environmental and social concerns are forcing sugarcane industries throughout the world to adopt green-cane harvesting. As pointed out in a paper from Brazil, advantages from leaving trash residues on the field following green cane harvesting include: a reduction in the use of herbicides, increased yields under conditions of marginal moisture, protection of the soil against erosion and high temperatures, decreased runoff and increased infiltration of soil water, increased organic matter and recycled nutrients, and improved sugar recovery in the mill as a result of shorter cut to crush intervals. These advantages are often countered by a reduction in harvesting and loading rates (manual and machine), the potential for reduced ratoon crop yields, and increases in the risk of insect and rodent pests.

In South Africa, where over 80% of the dry-land fields and 95% of the irrigated fields are burned, pressure is being exerted to establish a 5-km buffer around cities and towns. To alleviate South African grower concerns about green-cane harvesting, researchers are developing a simple decision support program that can be used by growers to decide for themselves on economic grounds whether to burn or to harvest green cane and where (which fields) not to trash. As pointed out during the session, green-cane harvesting and trashing may afford

sugarcane growers the additional economic benefit of selling carbon credits through the Clean Development Mechanism for developing countries that are part of the United Nations Kyoto Protocol Agreement on Climatic Change. In South Africa, eliminating burning of cane fields would have the equivalent effect of reducing CO_2 emissions by 600 000 tonnes annually. These savings in credits can be traded in exchanges in Chicago or London at a current value of approximately US $20/tonne of CO_2 equivalent. Other savings such as the adoption of minimum tillage and co-generation could increase the impact further.

Innovative Approaches to Nutrient Management.
Papers during this session primarily dealt with reducing fertilizer inputs. As a general rule, nitrogen (N) fertilizer rate recommendations are based on one variety and seldom updated. South African researchers, using hydroponically grown sugarcane, are finding genotypic differences in N-use efficiency for a range of commercial varieties. As a result, fertilizer rates are being adjusted based on the variety being grown. In further attempts at improving N management, researchers in South Africa and Swaziland developed N demand curves that span the entire crop season. They are attempting to marry the seasonal demand for N with the increasing use of drip irrigation systems. With scheduled "fertigation", growers will be able to apply N efficiently and reduce potential losses to the environment. To date, the N demand curves are only partially successful in correctly predicting N requirements. In another attempt to reduce fertilizer inputs, a split application of K at 30 followed by 90 kg/ha in Brazil resulted in higher yields than single in-furrow applications of K at up to 180 kg/ha.

In another attempt to improve N management, the Australians are exploring the possibility of using a system that monitors N in sugarcane supplied to the mill to provide growers with information on the N status of their crop. Diagnostic curves of juice amino-N versus relative sugar yield separated sugarcane crops into three crop N status groups: "low range" (<150 µg amino-N/mL of juice), "target range" (150 - 250 µg amino-N/mL of juice), and "excess range" (>250 µg amino-N/mL of juice). In Queensland, over 50% of the supplied cane was in the "excess range" of crop N status. As a result, growers have cut back on the amount of N applied to their fields. It is felt that with the adoption of near infrared technologies, analyses of N in stems or juice can be done rapidly and cost effectively.

The use of legume crop residues in Australia to benefit soil health and soil N content and ultimately to increase ratoon crop yields was discussed. Researchers have found that leaving the legume residue on the soil rather than ploughing it into the soil results in slower N mineralization rates and substantially increases the availability of this N for the following sugarcane crop.

In Australia, attempts are being made to develop a logical decision support package for use by growers and crop advisors that integrates a number of different components: increasing farmer knowledge of sugarcane soils and soil properties, understanding and managing nutrient processes, greater use of soil testing and leaf analysis, the development of innovative laboratory processes that better measure nutrient availability and loss processes, improved on-farm record keeping of nutrient use, the development of soil/site specific fertilizer recommendations, and the development of training courses for advisory staff and for cane growers. These efforts are an attempt to achieve sustainability, which implies maintaining soil fertility, minimizing off-site effects, and insuring profitable cane production.

New/Improved Practices to Increase Cane and Sugar Yields.
Papers in this session ranged from assessing the effects of crop age at harvest, variety, and period of planting on cane and sugar yields (India); to evaluating the use of high density planting through altered planting spacings (Mauritius and India); to optimising planting furrow width based on the variety being grown (Mauritius); to controlled traffic, minimum till, legume-based sugarcane cropping systems (Australia); to the need to improve water management strategies (Mauritius).

In Mauritius, increasing planting densities by the use of dual rows, close rows, and increased furrow widths are being explored. In the former, the planting of two and three cane rows spaced 0.5-m apart on a cane bed with 1.8-m centres is being compared to the standard single row planting on 1.6-m beds. Yield results are somewhat inconsistent, but there is a general trend to increase yields at the closer spacings with a reduction in density and without a need for increases in the amount of N fertilizer applied. Researchers are also evaluating planting furrow widths of 15 to 45 cm on bed centres of 1.3 to 1.6 m. To date, plant-cane and first-ratoon yields were generally higher at the wider density when planting rates were held constant. Differences in yield cannot be attributed to the interception of more solar radiation. Varieties may also influence the response to altered row spacing as reported from India where low tillering varieties benefited the most from the narrower spacings.

Research conducted in Australia is showing that breaking the monoculture of sugarcane with legume crops, reducing the amount of tillage, and avoiding trafficking crop rows with heavy machinery can each have positive effects on soil chemical, physical, and biological properties and ultimately crop yield.

In areas of the Mauritian sugar industry, crop yields are sometimes impacted by water shortages during drought periods. Researchers are exploring the use of alternative water resources such as sugar factory and municipal wastewaters, use of water retention chemicals, and improvements in irrigation like the centre pivot systems to

address water needs at these critical times.

New/Improved Practices to Increase Cane Biomass for the Production of Sugar/other Products.
Papers in this section primarily evolved around the addition of silicon to fields (Brazil); the use of filter press mud on fields to return nutrients to the soil (USA); use of fallowing and green manuring (Swaziland); intercropping of forages, green legumes, and mustards to supplement nutrition (India); the examination of the reduced growth phenomenon in sugarcane (Australia); and the utilization of harvest scheduling systems that take into account crop age, variety, and time of harvest (U.S.A).

More and more countries are seeing a multitude of benefits, most importantly increased yields, from the supplemental application of silicon to cane fields at planting. Silica is an essential element for plant growth and silicon accumulation within the plant is being linked to: improved resistance to insects and diseases, reduced lodging, enhanced tolerance to frost and water stress, and increased photosynthetic capacity. In Brazil, addition of silicon in the form of cement to sandy soils can improve yields in both plant and ratoon crops by at least 11%.

In Swaziland, plant cane yields were improved by 16 to 29% after bare fallowing and 40 to 50% after green manuring as compared to continuous sugarcane. Improvements in crop yields were not obtained in the subsequent ratoon crops. In India, inter-cropping has provided an alternative food source for livestock, has improved soil health, improved sugarcane yields, and ultimately improved the profitability of their sugarcane-based production systems.

Biomass accumulation in sugarcane declines as the growing season progresses, as well as other crops, despite a seemingly adequate supply of the inputs necessary for plant growth. The existence of this reduced growth phenomenon (RGP) in sugarcane was explored in Australia. The RGP was found to occur more frequently in plant crops, than in ratoon crops. The RGP was not due to depressed growth in response to restricted temperature or solar radiation. However, specific leaf N, lodging events and the loss of stalks predominantly during the later period of growth in the plant crops, are likely to have influenced the development of the RGP.

Moving Towards a Delicate Balance Among Sugarcane Production, Natural Resource Utilization, Environmental Impact,
and Economics.
Papers in this session dealt with: the use of precision agriculture technologies to limit the crop's impact on the environment (Mauritius); the impact of salinity (Australia); soil erosion and phosphorus transfer from fields and the crop's contribution to pollution (Mauritius); management strategies to reduce particulate emissions during the burning of standing cane (Mauritius); the development of a predictive model to evaluate factors that may affect greenhouse gas emission from sugarcane fields (Australia); the actual use of sugarcane fields as a disposal route for organic waste produced by municipalities (Mauritius); and educational efforts designed to help growers and millers in identifying practices that can reduce the crop's impact on the environment and the publishing of the industry's adoption of these practices to demonstrate the industry's attempt to be good environmental stewards (South Africa).

Precision agriculture offers sugarcane growers an opportunity to insure sustainability and profitability. Studies are being conducted in Mauritius using yield monitors mounted on chopper harvesters to establish and map spatial yield and soil variability. Once existence of variability is identified, growers will be able to establish zones in these fields that may require site-specific changes in management practices and ultimately result in increased crop yields with a reduced impact on the environment.

A re-assessment of the impact of soil salinity on sugarcane yields in Australia was conducted. Though yields were reduced as salinity levels increased in both the plant cane and ratoon crops, results suggest that ratoon crops are more sensitive and that new standards are needed especially since ratoon crops constitute the greater percentage of the land area devoted to sugarcane. Results also showed the impact of increasing salinity levels on cane quality as well as on cane yields.

Sugarcane comprises 45% of Mauritius' total land area. As a result, the sugarcane industry is identified as a major polluter. Much research is being conducted in Mauritius to address this issue. For instance, increasing phosphorus (P) levels in many inland surface waters are being linked to sediment transport from cane fields occurring during rainstorm events. In one study, researchers are finding that most of the sediment and P were moved early during the runoff event. The results suggest that methods that control sediment and nutrient loss are needed. In a second study, researchers are using methodology adopted for the Non-Point Source (NPS) pollution evaluation to quantify the sugarcane crop's contribution to the pollution in the area. Researchers are also attempting to develop surface and subsurface models based on topography, geology, and land use using GIS tools, a Soil and Water Assessment Tool, and a Hydrogeomorphic Analysis of Regional Spatial Data tool. Using these, as well as other models, a better picture of sugarcane's contribution to NPS is emerging.

The emission and deposition of large amounts of particulate matter or ash into neighbouring residential and commercial areas during the burning of standing cane is jeopardizing this valuable harvesting tool in all parts of the world. In Mauritius, early morning burning when the wind is low and dew is usually present (cool burning) was

shown to reduce particulate matter by 60% when compared to conventional afternoon burns. Cool burning is now a common practice in Mauritius.

Methodology was presented that enables different sugarcane production scenarios in Australia to be evaluated on the basis of their potential to reduce greenhouse gas emissions. The simulation results indicate that burning is the greatest source of greenhouse gas emissions and that the optimum production per unit of greenhouse gas emissions can be achieved by introducing green cane trash blankets and a legume fallow into the cropping system. An economic analysis of the potential differences between private and public benefits associated with each scenario indicates that the greatest financial benefits can be accrued to both sectors when green cane trash blankets and fallow periods are incorporated into the cropping system.

Disposal of organic waste generated by industries and municipalities is a costly problem that is increasingly being met with more stringent environmental regulations. In Mauritius, researchers are exploring the re-use of these organic wastes in sugarcane fields as a possible avenue for their use. Researchers are finding that sewage sludge disposal presents little risk of groundwater contamination by heavy metals and that the material supplies valuable N. They feel that sugarcane fields can provide a safe outlet and a sustainable option for the disposal of organic waste.

As pointed out in a paper from South Africa, sugarcane growers worldwide are increasingly coming under pressure from environmental groups because of perceived negative impacts such as water availability, water contamination, cane burning, reduced soil quality, use of agrochemicals, and lack of bio-diversity. To address the issue with the public, a multi-faceted environmental strategy is being proposed in South Africa. The strategy will involve the implementation of an environmental management system, development of environmental publications, promotion of positive environmental impacts, promotion of environmental awareness in schools, development of environmental education programs, and sponsoring of educational grants in the environmental field.

Information Technology in Agronomic Practices.
Papers in this session dealt with the development of decision support systems to aid growers and millers. In the U.S.A., the Florida sugarcane industry developed a ground-based network of electronic recording thermometers to generate GIS-based data to report the regional distribution and duration of low temperatures following freeze events. They are using the information to develop post-freeze harvesting schedules. In Australia, a yield simulation model is being developed to improve harvest planning and yield estimates on large farms. The system is based on the CANEGRO crop model with the harvest-planning module of CanePro also being employed. The system is significantly more accurate in estimating yields than estate-generated estimates.

In South Africa, a decision support program known as VTYECON was developed to calculate and optimise the net economic value of varieties under specific agroclimatic and economic conditions. The system is available on the Internet. The South African researchers have also developed a Web-based system to support strategic and tactical decisions regarding sugarcane agronomy. The system is being used to: benchmark yield to identify nutritional, weed, and stalk population problems; assess the suitability of rain-fed crops for chemical ripening; assist with yield forecasting; assist with understanding peculiar crop responses to the environment; and schedule irrigations. In Thailand, a computer program, CaneFert 1.0, is being developed to accurately determine recommendations for the use of N, P, and K based on the properties of the country's various soil series. Results are being compared to those generated using CANEGRO 3.5. The incorporation of real time-dew point temperatures and wind runs is being evaluated in Mauritius in an attempt to further enhance the performance of the CANE-DSSAT models in that country.

Researchers in South Africa, Mauritius, and Swaziland are proposing the establishment of a multi-national consortium to develop and maintain the Decision Support System for Agrotechnology Transfers (DSSAT) Canegro Sugarcane Model. The aim would be to insure the continued maintenance and inclusion of sugarcane modelling advances into the DSSAT and, with some financial contribution by consortium members, a more robust model that is tested under a wider range of growing conditions and genotypes.

Field Tour.
The participants were afforded an opportunity to tour the Mauritian sugar industry. These tours included stops to see the industry's attempt to prepare fields for mechanization that included extensive and expensive practices to remove rocks from fields, its attempt to compost and return the composted material to the fields, its attempts to utilize precision agriculture techniques which included the development of yield monitors for chopper harvesters, its battle to provide irrigation while conserving water usage, its control of weeds and the use of ripeners, its attempts at increasing stalk populations and crop yields through the manipulation of inter-row plant spacings, and the need to apply valuable nutrients such as silicon during the planting operation to insure optimum crop yields and stubble longevity.

Business Meeting.
Topics discussed at the business meeting at the conclusion of the workshop included: the development of a theme and session topics for the Agronomy sessions at the 2005 ISSCT Congress in Guatemala, membership on

the Agronomy Committee, the venue for the next Agronomy Workshop, and ISSCT publications dealing with agronomic issues. The chairman of the Agronomy Committee was asked to summarize and distribute suggested themes and session topics developed in the business meeting to the participants and to incorporate their responses when developing the Agronomy Session for the Congress. Based on recommendations from the sectional membership, the Agronomy Chairman will develop a list of potential committee members that will be forwarded to ISSCT's Technical Program and Executive Committees for consideration in assigning membership on the Agronomy Committee. An offer was received from Thailand to host the next ISSCT Agronomy Workshop.

At the 24th Congress in Australia, the ISSCT Executive Committee approved a request authorizing the Agronomy Section to develop an ISSCT-sponsored Sugarcane Nutrition Manual. A committee meeting was held and an outline of activities was developed during the workshop. It is hoped that a draft of the manual can be developed by the 2005 Congress. Other publications discussed included the development of an international soil classification standard and an environmental management system for sugarcane. Finally, the utility of the CANEGRO model was amply demonstrated during the Workshop. Financial support is needed to continually upgrade and improve the predictive capabilities of this model. The development of a CANEGRO Modelling Consortium was put forth which would include a request for some financial support from member countries, as well as possibly ISSCT.

Conclusion

Social, political, and environmental concerns, while threatening the time-honoured process of producing sugarcane, are actually creating opportunities for the industry as it strives to remain sustainable and profitable. Adding to the creation of these opportunities are the recent advances in computer and satellite technology and the use of decision support software that now allows growers, extension officers, and researchers to make educated estimates/predictions as to the yield potential of a crop when one or more factors, be it available moisture, nutrition, etc., are manipulated. The industry's shift to green-cane harvesting has also forced it to evaluate the potential impact of the residues generated on soil health. Economic and long-term soil health concerns have heightened the realization of the importance of returning plant residues to the soil and has also allowed the industry to explore the use of green manure crops. Ultimately, these interests are creating "opportunities" for the sugarcane industry to move forward as a viable agronomic industry into the 21st century.

Acknowledgment

The Agronomy Section Committee consisting of: E. Richard, Jr. (Chairman, USA), R. Ng Kee Kwong (Mauritius), G. Korndörfer (Brazil), J. Meyer (South Africa), G. Kingston (Australia), J. Shine (USA), and G. McMahon (Australia) thanks the Mauritian Sugarcane Industry and members of the MSIRI for hosting the workshop.