PRECISION AGRICULTURE FOR SUGAR CANE IN MAURITIUS

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Abstract

Precision agriculture, embracing new information and communication technologies, offers the possibility for improving crop production through management of spatial variability leading to profitability and protection of the environment. While studies on precision agriculture for sugar cane were initiated elsewhere, a program was implemented in Mauritius to investigate its applicability and effectiveness in the sugar cane industry. Yield monitoring is a first approach to be followed by soil variability mapping. Preliminary results of spatial yield analyses have demonstrated that there is important within-block and temporal yield variation. Related information technology tools are already in use to promote precision agriculture within a total system.

Introduction

Information and communication technologies are impacting on our daily life, and there is no realm of science, research and discipline that is not under their influence. In agriculture, such technologies as remote sensing, geographical information systems (GIS) and global positioning systems (GPS) have been adopted for improved management of land and crop production. In the light of this adoption, new management philosophies for sustainable and profitable crop production, as well as affording protection to the environment, are evolving. It is logically realised that terrain specific conditions can be assessed and inputs prescribed to specific sites with the help of these technologies.

Precision agriculture is the form of agricultural science that is developing to include the use of new information and communication technologies to arrive at management strategies that will optimise production, profitability and protection to the environment. Several definitions of precision agriculture exist in the literature. It is worthy to note that it is about information gathering, management planning, and field operations that will improve the understanding and management of soil and landscape resources so that crop inputs can be used more efficiently than with conventional uniform-application strategies. It integrates the new information and communication technologies.

Many conferences, symposia and journals present results and discuss the issues of precision agriculture, whereas research centres of precision agriculture are increasing in number. Philosophies of precision agriculture have been put forward (Williams, 2000), while a statistical concept of the 'null hypothesis' of precision agriculture has been discussed by McBratney and Whelan (1999). Efforts to evaluate methods of precision agriculture to reduce cost of inputs/production are also not spared (Anon., 2000). Research on precision agriculture for sugar cane started fairly recently (Cox et al., 1996; Bramley and McMahon, 1997; Lockhart and Murray, 1997; Saraiva et al., 1999), though it has been on going for many years in relation to other crops such as corn, soybean, wheat, oat, etc. In Mauritius, interest in precision agriculture has been aroused as a result of its possibilities to respond to certain important objectives which the sugar industry has set. The paper presents the background and projects for the application of precision agriculture for sugar cane in Mauritius.

Why precision agriculture?

The perspective of precision agriculture for sugar cane in Mauritius has been previously described (Jhoy and Autrey, 1998). The Mauritian sugar industry is forced by circumstances to mechanise all its cultural operations to reduce costs of production and to stay competitive. More efficient irrigation systems are operated. Steps have been taken to implement special land planning measures, to enlarge the size of fields and to proceed with total mechanisation of cultural practices. In the wake of this, personnel control on field visits and operations will be reduced and any anomaly occurring within large blocks of fields may escape attention. Precisely, information technologies such as high-resolution satellite imageries and/or digital infrared photography, coupled with GPS available within a precision agriculture system, will be quite useful in providing detection of anomalies and pinpointing where the remedies are to be applied.

Owing to the geological nature of parent materials of the country, which has given rise to flat, undulating as well as hummocky terrain, spatial variability of natural features (topography, soils, and climate) are inherent. As a result, site specific management of crops would be conducive to applications of variable inputs which could lead to optimisation of inputs, crop production and the possibility of reducing cost of production. These and other factors combined make precision agriculture, specifically in the sugar cane industry, a worthy candidate for investigation in Mauritius.

KEYWORDS: Competitiveness, Information Technologies, Mechanisation, Spatial Variability, Yield Monitoring.
Background

The platform for precision agriculture for sugar cane in Mauritius has been set, as a result of the introduction of appropriate technologies in the recent past in spite of the fact that the concept of precision agriculture as is known today was not perceived as such. In the 1970s, computerised databases, known as Land Indexes, comprising land suitability, physical, climatic and crop characteristics of each sugar cane field were compiled for different groups of cane growers. The resulting computer print-outs listing soil types, rainfall totals, crop variety, yield, crop suitability, etc, for each cane field were distributed to growers for land and crop planning. In the 1990s, a GIS for the management of sugar cane land (GIS-CANE), integrating the Land Index databases, was developed (Jhoty et al., 1995). Growers were made aware of the possibilities of the GIS, and gradually adopted it as a decision support tool for land and crop management. Information being available on a field by field basis in GISCANE demonstrates the steps that were taken to proceed towards precision agriculture. In 1996, highly accurate real-time kinematic and dual frequency GPS receivers were acquired and have been used in the production of large scale contour maps and for siting centre pivot irrigation systems (Jhoty, 1999).

Remote sensing has been applied all through the years using aerial photographs and satellite imageries. Infrared photography enabled the evaluation of damage caused to sugar cane by the attack of the soft scale insect, Pulvinaria leceryi (Anon., 1977), while recent 1999 satellite images were useful in assessing the extent of severe drought damage in sugar cane. The SPOT satellite images used enabled the precise mapping of cane areas irrigated by the centre pivot systems. With the availability of high resolution satellite imageries, the application of these imageries for precision agriculture will be highly valuable in detecting anomalies occurring in fields, as illustrated by a specific use of satellite imagery to detect a defective operation of a centre pivot irrigation system causing stress in sugar cane (Anon., 2001). Sugar cane crop modelling has also been recently investigated for the assessment of yield potential and variability (Cheeroo-Nayamuth et al., 2000). Given the applications of the aforesaid technologies, it is evident that precision agriculture as is presently defined is not far from being achieved.

Project implementation

A project on precision agriculture, phased in time, has been initiated. The results of each phase will in a sort provide the basis for proceeding with the execution of the rest of phases. Phase I has been completed and demonstrated the importance of field-to-field and temporal yield variation (Figure 1). The causes of these variations will be addressed, in Phase II, to determine whether they were/are due to soil variability or irrigation water efficiency. Phase II, starting in July 2001 and making use of a yield monitoring system and a soil electromagnetic meter, will aim at

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Fig. 1—Temporal and within-block cane yield variation.

N.B. Fields 1029 & 1030 irrigated by dragline; fields 1031 to 1035 by centre pivot system.

* Planted in 1995 (short season).
identifying within field yield and soil variability, respectively. If Phase II is concluded positively, variable rate technology for fertilisers and herbicide applications will then be investigated in Phase III. The final assessment will be the demonstration of the effectiveness of precision agriculture in providing answers to such questions as:

- What are the factors that most affect yield within and among fields?
- Will spatial variability lead to effective variable rate applications?
- How precise can variable rate inputs be applied?
- Will variable inputs optimise yield while reducing total inputs?
- How cost-effective will precision agriculture be?
- Will it improve the existing philosophy of field and crop management?
- Will it be possible to extend precision agriculture to all planters?

Towards a total system

With the set of spatial databases compiled and information technologies acquired at the Mauritius Sugar Industry Research Institute, coupled with the acquisition of further information technology tools, the development towards a total system for precision agriculture is well under way. The main components of such a total system are shown in Figure 2. The total system will, if successfully realised, provide the necessary knowledge base within a decision support system to output strategies of land and crop management. These strategies will ensure the sustainability and economics of crop production while growers adjust to changing socio-economic conditions.

Conclusion

Circumstances dictating the sugar industry to proceed with total mechanisation of cultural practices and reducing cost of production for being competitive motivate the investigation of precision agriculture in Mauritius. This is prompted more so by the fact that information technologies within a precision agriculture system are acquired, and also spatial variability of land is inherent to allow variable rate input. Results have to prove that precision agriculture for sugar cane is important, prompt in providing remedies and cost-effective for a better control or optimisation of inputs and crop production.

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Fig. 2—Main components of a total system for precision agriculture in Mauritius.

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Résumé

L’agriculture de précision offre la possibilité d’améliorer et de rentabiliser la production de culture, et de préserver l’environnement, par la gestion de la variabilité dans les champs. Elle utilise les nouvelles technologies de l’informatique et de la communication. Des études sur l’application de l’agriculture de précision pour la canne à sucre ont été initiées dans certains pays. À Maurice, une étude mise en place vise, en premier lieu, la réalisation de la cartographie des rendements et en suite la cartographie de la variabilité du sol. Les résultats préliminaires découlant des analyses spatiales ont démontré que la variabilité de rendement aux champs est significative aussi bien dans les blocs que dans le temps. Certains outils informatiques sont déjà utilisés, dans un système total de gestion, pour promouvoir l’agriculture de précision.

AGRICULTURA DE PRECISION PARA LA CAÑA DE AZÚCAR EN MAURICIO

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Resumen

La agricultura de precisión, a partir del uso de nuevas tecnologías de información y comunicación, ofrece la posibilidad para mejorar la producción por medio del manejo de la variabilidad espacial conduciendo a obtener una mayor rentabilidad y mayor protección al medio ambiente. Mientras en otras partes se están iniciando estudios sobre agricultura de precisión, en la isla de Mauricio se inició un programa para investigar su aplicabilidad y efectividad en la industria de azucarera. El mapeo de la producción es el primer paso seguido por el mapeo de la variabilidad del suelo. Los resultados preliminares de los análisis espaciales han demostrado que hay variaciones importantes dentro de los campos, además de las variaciones temporales. Las herramientas tecnológicas ya están en uso para promover el uso de la agricultura de precisión como un sistema total.