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# AGRICULTURAL MANAGEMENT TECHNOLOGY IN THE SUGARCANE ETHANOL INDUSTRY

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## INTRODUCTION

Agricultural management is understood as the execution of administrative functions (organization, planning, leading and control) by an administrative team, under the lead of a manager, usually appointed in the mills by the Agricultural Manager, with the purpose to produce and transport sugarcane to the mills/distilleries.

Agricultural management may be part of the overall flowchart of the sugarcane producer, mills or distillery or even a group of mills. In any of the three cases, agricultural management, given its specific function[1] of production and transportation, is located at a tactical/operational level within hierarchy of the company.

For technology management it is understood as information technologies or telematics (computation – hardware and software – and telecommunications) applied to management. However, given the strong correlation between technological and organizational innovations (RAUPP, 2001), practical organizational procedures should also be considered as management technology. These procedures derive from management theories or models, which can be divided into: i) functional and ii) process (or quality).

This main purpose of this chapter is to synthesize the Terms of Reference from the Workshop entitled “Agricultural Management in the Sugarcane Ethanol Industry”[2], and the workshop contributions. This chapter is divided into six parts. The first part characterizes the diversity of situations in which agricultural management occurs. Starting from situations where the management model and technology management are more developed the other four parts examine organizational innovations (process management and ERP) and technological innovations (software, SIG and telecommunications). The final consideration, based on the Workshop outcome, looks at ways to promote technological advances in agricultural management in the sugarcane and ethanol industry.

Organizational practices and technology management in the sugarcane alcohol industry are distributed in various institutions. Public research institutions are highlighted, particularly individuals or research groups in universities such as ESALQ/USP, DEP/UFSCAR, FEAGRI/UNICAMP, FCA/UNESP Jaboticabal, or research institutes such as INPE; private research institutions, particularly

[1] In addition to functional analysis – production and commercialization, human resources, finances –,management analysis can be strategic, comprising the company and its environment, and sectorial, comprising the actors of the sugarcane alcohol chain (equipment industry and inputs, suppliers, distilleries and mills, distributors and intermediary consumers) and its associations (ORPLANA, UNICA, …) with the State, the market and the society.

[2] This Workshop integrated the research project “Guidelines of Public Policies for the scientific and technological research in bioenergy in the State of São Paulo”, financed by FAPESP. Further information about the project can be obtained in: <www.apta.sp.gov.br/cana>.

**TABLE 1** Grouping of 281 C-S mills, 2006/2007 mills, by quartile interval.

| Quartile interval | Annual milling, average 2006/2007 (thousand ton.) | % of the total milled sugarcane 2006/2007 |
|---|---|---|
| $< 3^{th}$ | 3,243 | 53 |
| $< 2^{nd}$ and $> 3^{th}$ | 1,608 | 26 |
| $< 1^{st}$ and $> 2^{nd}$ | 968 | 16 |
| $> 1^{st}$ | 340 | 6 |

*Source*: UNICA website (available at: <www.unica.com.br>).

the CTC. Consultancies specialized on sugarcane and ethanol management, on ERP; experts in hardware and software; geotechnologies (e.g. sensors, images, and gps) and telecommunications (e.g. PDAs and cell phones), (KUBOTA, 2006). It also includes mills/distilleries, technology and practices users.

Some professionals that work in management consultancies and agricultural management are university graduate and postgraduate students; others have attended leading private research centers such as the Centro de Tecnologia Copersucar (Copersucar Technology Center), currently Centro de Tecnologia Canavieira (Sugarcane Technology Center). Some companies and mills have also partnerships with research institutions, to train their personnel in R&D or in specific courses for the industry – e.g. CEPEGE/ESALQ: Investment and Management in the Sugarcane Alcohol Agro-industry), or the GVPEC/FGV, EAESP and IDE (Agrobusiness: Economy and Management of the Sugarcane Alcohol Industry).

## ORGANIZATIONAL CONTEXT WITHIN WHICH SUGARCANE MANAGEMENT TAKES PLACE

### From suppliers to industrial groups

When thinking on sugarcane production, one generally imagines a mill producing sugar and ethanol), or a distillery (producing ethanol only); and/or the integration of the agro-industrial and ethanol chain. This image, is in fact true because 61.8%[3] of all sugarcane processed in the country comes from integrated agro industrial units (even if some production components are carried out by partners). There is a considerable diversity among the 281[4] mills of the Center-South, as shown in Table 1; the milling data shown in the table corresponds to the 2006/2007 harvest season, totaling 431 million tons of cane, grouped in quartiles

The rest, 39.2% (even if partly owned by the mills' shareholders) of the sugarcane crashed is produced by third parties or independent suppliers. Among these suppliers there is also great variety of producers, ranging from 250 ha to 20 ha. ORPLANA which represents 26 suppliers' associations in SP, MG and MT, with a total of 14,222 producers, and 73 million tons of milled sugarcane in the 2006/2007 harvest, (20% of milled sugarcane in C-S region); 13,980 producers responsible for 68.6 million tons (26% of the milled sugarcane), are based in the Sate of SP, as illustrated in Table 2.

The diversity of companies in the agricultural and agro-industrial sectors means that management production systems very considerably. For example, small suppliers can manage their own production without formalizing any techno-economic management agreement, though indirectly they benefit from it. On the other extreme, large

[3] For the 2006/2007 season, according to the Balanço Nacional de Cana-de-açúcar e Agroenergia 2007 (National Balance of Sugarcane and Agroenergy 2007)

[4] In the milling ranking available in the UNICA website in the 2006/2007 and 2007/2008 season are 281 mills in C-S, being 169 in SP. In the record of mills available in the MAPA website, up to 07.11.2008, are 315 mills in C-S, being 184 in SP.

**TABLE 2** Profile of sugarcane producers of the State of São Paulo – 2006/07 harvest season. Data calculated from the "Pagamento de Cana pela Qualidade" (Payment by Sugarcane Quality).

| Production (in tons) | Number of growers | % of Growers | Average areas (ha) | Productions (t) | % of Production |
|---|---|---|---|---|---|
| < 200 | 1,582 | 11.3 | 1 | 190,051 | 0.3 |
| 201 to 800 | 3,758 | 26.9 | 6 | 1,754,667 | 2.6 |
| 801 to 4.000 | 5,455 | 39 | 22 | 10,324,399 | 15 |
| 4.000 to 10.000 | 1,788 | 12.8 | 74 | 11,257,936 | 16.4 |
| > 10.000 | 1,397 | 10 | 381 | 45,121,937 | 65.7 |
| **Total** | 13,980 | 100 | 58 | 68,648,990 | 100 |

*Source*: ORPLANA (available at: <www.orplana.com.br>).

mills have already professionalized management, supported by computing systems that can provide the shareholders with greater transparency of management actions while at the same time providing instruments to assess the performance of the managers themselves.

More recently, two opposite movements have brought greater interest to the management of sugarcane production. The first refers to the formation of industrial groups, a horizontal integration, comprising several industrial units and farms. According to CARVALHO (2007)[5], in 2006/2007 harvest in Center-South (C-S) region, 154 mills (or 58% of the C-S mills), were controlled by 67 groups responsible for 73% of sugarcane. The largest group is COSAN with 18 mills and 14% of the crashed sugarcane in the state of São Paulo in the 2006/2007 harvest season. The pressure on management, especially fiscal, is intense. This is because a driver of unit A, driving a truck of unit B, and carrying sugarcane of a farm of unit C, could be taking the cane to a mill in unit D. Simulations on the optimization of transport logistics of sugarcane, after the administrative integration between two mills, have shown a 30% reduction in the overall transportation costs.

The second movement refers to third parties or outsourcing (ALVES, 1998). In the mills, besides "outsourcing" by sugarcane suppliers, several units [transport of personnel, cultivation of ratoon cane, application of herbicides, mechanical harvesting, sugarcane transport (shipment & transshipment), and equipment rental (i.e. sugarcane trucks and crawler dozers), is currently used extensively in service management. For example, RIOS (2007) quotes a company with 180 buses that provides transport for the personnel of 5 mills in the region of Presidente Prudente. According to Agricultural Indicators of 2003/2004 season of the IDEA Group, based on data of 42 mills and distilleries in the C-S, 29% and 79% of shipment and transportation, respectively, of sugarcane in these mills was carried out by third parties; 65% of work related to biological control was also outsourced. In addition, the most labor intensive agricultural activities e.g. planting, chemical control, sugarcane cutters and tractor driver[6] /operators, are also outsourced, as shown in Table 3.

Despite the fact that sugarcane production areas are quite heterogeneous, if considered

[5] VI Conferência Internacional Datagro (Datagro International Conference), Eduardo Pereira de Carvalho (Unica).

[6] The Agrop, that belongs to the Junqueira family, traditional sugarcane business, noticed the lack of good quality manpower and started outsourcing in farms and mills. Its 550 workers are submitted to health control, learn how to use safety equipment and the correct handling of working tools. The company provides also legal, tributary, work safety and engineering advice.. Founded on 1995, after a low start, the company has expanded rapidly in recent years Roberto Junqueira, of 29 years old, agriculture director of Agrop. (**Exame**, Os inovadores da cana – The sugarcane innovators, 24.08.2006)

**TABLE 3** Degree of outsourcing and relative importance of the roles of direct agricultural labor.

| Roles of the direct agricultural labor | Degree of outsourcing and the role of direct labor force (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Daily crash capacity (t.day$^{-1}$) | | | | | | | |
| | < 3,000 | | 3,000-6,000 | | 6,000-9,000 | | > 9,000 | |
| Rural area: planting | 79 | 16.0 | 80 | 15.9 | 76 | 19.4 | 90 | 17.6 |
| Rural area: weeding | 70 | 6.4 | 35 | 4.7 | 38 | 3.1 | 57 | 8.1 |
| Rural area: Chemical control | 47 | 5.6 | 89 | 4.4 | 56 | 5.2 | 49 | 5.0 |
| Rural area: General services | 44 | 6.5 | 39 | 11.2 | 28 | 7.3 | 40 | 3.3 |
| Operator/tractor driver | 34 | 6.4 | 39 | 8.3 | 35 | 8.1 | 37 | 14.5 |
| Driver | 37 | 5.5 | 40 | 6.1 | 32 | 6.7 | 38 | 10.6 |
| Sugarcane burner | 13 | 0.9 | 11 | 0.6 | 3 | 1.1 | 28 | 0.5 |
| Sugarcane cutter | 5 | 49.4 | 12 | 44.2 | 5 | 45.9 | 14 | 35.9 |
| Coupler (Julieta) | 2 | 0.9 | 6 | 0.6 | 0 | 0.7 | 22 | 1.7 |
| Load trimmer | 0 | 0.2 | 0 | 0.2 | 0 | 0.2 | 0 | 0.4 |
| Suga rcane picker | 7 | 2.4 | 1 | 3.7 | 0 | 2.4 | 11 | 2.4 |
| **Total** | **42** | **100** | **32** | **100** | **33** | **100** | **40** | **100** |

*Source*: Data from IDEA.

within the agricultural business, mills and similar groups, the state regulation kept until the end of the 1980's, was very favorable and less restringing when compared to any other business. Early in 1990's, thanks to deregulation, greater competition started between the agro-industrial companies, promoting a race that intensified the rationalization of productive processes, in search of greater technical efficiency and resulting in a significant cost reduction, including management, and thus allowing preserving or expanding their market share.

This race created a demand for advisory/consultancy companies, offering management solutions already been adopted by other branches of activities, as already indicated, to improve the financial performance; such activities inspired technological innovations in management, stimulating the entry of new companies into this market. There was also Sate support by means of a financing program for the adoption of information technology, through the MCT Ordinance MCT n. 200, of November 18th, 1994.

These changes incorporated new management models – from functional to processes – demanding a new cultural attitude and improved organizational practices; the adoption of IT tools, new and better data also enriched and facilitated decision making. These changes e.g. new and processing of data, and the speed of operations, allowed to increase the time frequency and the number of variables to be considered in the models for supporting the decision making process. More recently, geo-technologies have increase time frequency, physical scales and the wave bands of aerial images, incorporating spatial dimensions to support decision making, enriching the possibilities of management tools, from precision agriculture to the prevision of crop yield. Precision agriculture is a direct reflection of management technologies e.g. technological advances in remote sensors, Geographic Information System – GIS, and on-board electronics.

The incorporation of new management models and technologies did not occur in a uniform manner within the industry; the largest mills/

distilleries are most active in this area. In 1998, the essay "Competitivity of the Sugarcane agroindustry System", carried out by PENSA/FIA/FEA/USP, warned that the mills that avoid government subsidies, as strategy for government support, also were conducting their strategies for technological improvement of commercial relations, in addition to integrating partnerships and syndicates; while mills that kept high dependence of government support did not adopted them. The Essay about the "Competitivity of the Sugarcane Agroindustry System and Sourcing of New Ventures", authored by the Evaldo Loi Institute and SEBRAE in 2005, grouped mills according to their survival perspective within current deregulation, into two sets: i) those mills that benefit from state support during the most interventionist period, and ii) mills that did not benefit much from state support, facing serious difficulties to survive in the current environment.

More recently, a study "Productive Chain of Agroenergy" (2007), coordinated by Batalha and Buainain, with technical support from Paulilo and Mello, Freitas Vian and Belik, emphasizes the need for good management and technological development if Brazil is to keep its competitive position. The main innovation initiatives observed in the most competitive units are: (a) Professionalization of mills by hiring management executives, (b) Internal networking for the flow of information ,with the adoption of Enterprise Resources Planning – ERP; systems for integrating management processes, and use of Electronic Data Interchange – EDI, with business partners; (c) Harvest planning and planting with use of expert software (optimization through non linear equations), (d) Integrated Geoprocessing software with remote sensing and satellite images (Georeferenced Information System – GIS), with the purpose of monitoring the development of sugarcane plantations, (e) Digital control for use of equipment (bar codes, radiofrequency), monitoring of tractors by satellite, and (f) Adoption of precision agriculture by hiring service providers for agricultural operations.

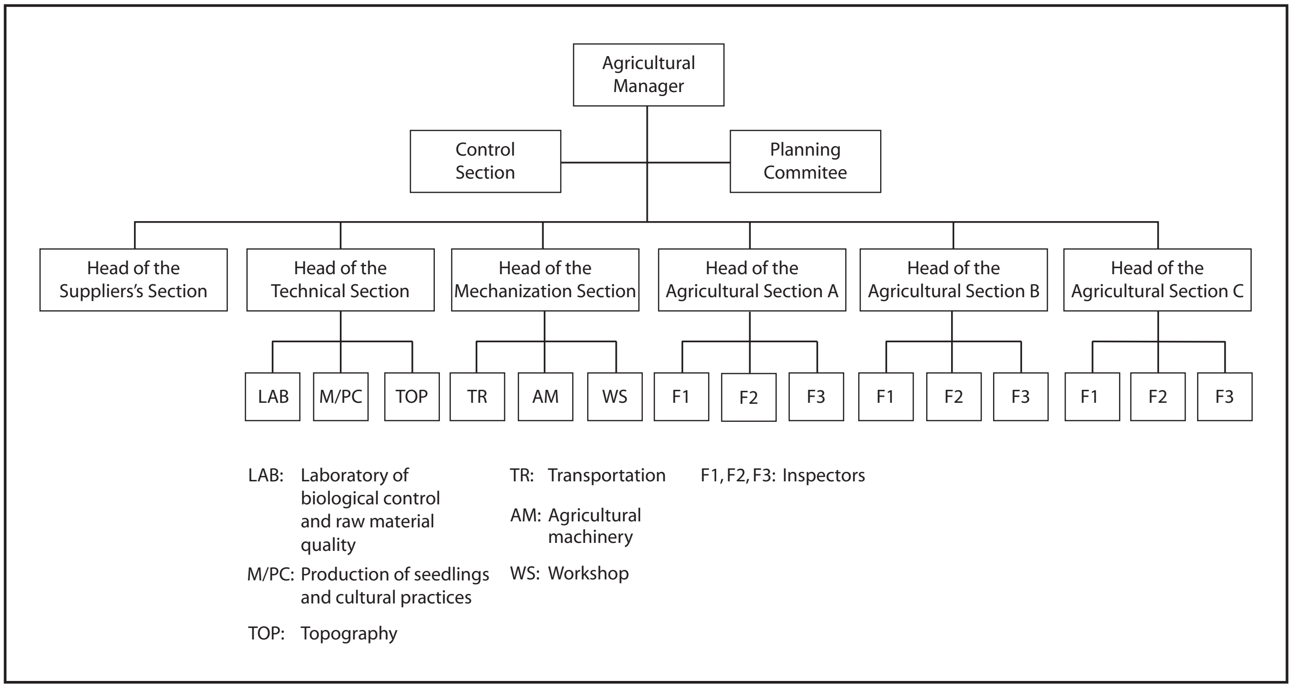
These innovations promoted the transition between functional and procedural management models, with increasing degrees of IT adoption, comprising data collection and transmission systems, and data analysis systems to support decision making, – from the sensors (and actuators) to software. Thus, the more recent innovation in management models are of a crosswise kind (or non disruptive), allowing transition processes with gradual incorporation of the new model.

## PROCESS AND ERP MANAGEMENT

### From functional to processes models

BRUGNARO *et al*. (1981) book is the only one in Brazil that deals exclusively with the theme of sugarcane agriculture management. The book was at the vanguard of conceptions and management models and helped to consolidate company management over the productive economy. Also, when focusing in production management of a single culture, it helped to advance techno-economic aspects of planning and organizational structures in agricultural management. In addition, it enhanced the role of leadership and the specialization of teams, and so many other aspects of agricultural management hardly known before. At a time when the use of IT in mills was still very restricted, the book led to a new phase on functional models in sugarcane and ethanol management. In this book prevailed the vertically hierarchical relations of employees, functionally grouped, focusing on good performance. Figure 1 shows the functional model of these authors and Figure 2 the difficulties of interdepartmental relations in vertical functional structures – one of the biggest criticisms of the functional model.

The deregulation of the industry and the search by the mills to improve business performance opened up new possibilities for consultancy and management advisers to influence old behavior and practices, especially in areas of management of information/knowledge and the relation with clients/suppliers that were critical. These "new" models favored horizontal relations, promoting a business vision like a (macro) process, in which work and resources flows integrate, aggregating value, conditioned by relations with




Obs.: 1) The number of Agricultural Heads, as the number of inspectors per section can vary from case to case.
2) The Agricultural Sections will be mentioned in the text only as "Sections" in most cases.

*Source*: BRUGNARO *et al*. (1981).

**FIGURE 1** Functional flowchart of agricultural management.

clients and suppliers (internal and external). Employers requested that employees performed their functional role in multidisciplinary teams, controlling the results and assessing, criticizing and improving their activities continuously. The reductions of managers, improved performance, greater motivation and flexible teams have been the main benefits of process management[7].

A representation of an organizational structure of agricultural management of a sugarcane ethanol plant in the process model is depicted in Figure 3. As can be observed, the main process – (business) is supported by other support processes (integration and management), valuing the production area in relation to the other functional areas of the company. When compared to Figure 1, it can also be observed that several "Head of Sections", responsible for the management of several activities and operations carried out in agro-industry, are replaced by "Head of Activities", responsible for the same activity, performed in several sections.

This new culture of processes management is gradually being disseminated/implemented and does not overlaps, completely, the functional models, as highlighted by DAVENPORT (1994), TACHIZAWA and SCAICO (1997). GONÇALVES (2002) depicts 5 stages in the evolution of a company toward process organization (Table 4). Company management advisers provide support to this transitional phase of management models, minimizing negative impacts while accelerating the positive impacts.

The implementation and operation of the principles of process management and the adoption of information systems that incorporated these principles were initially consolidated in department of industrial production of the company. The information systems were developed with environmental management databases, giving support to

[7] The ISO 9000 and 14000 family, on the quality and environmental management, respectively, the experience of production management of TOYOTA lean management and total quality management – TQM, were considered as having the same basis for process management models.

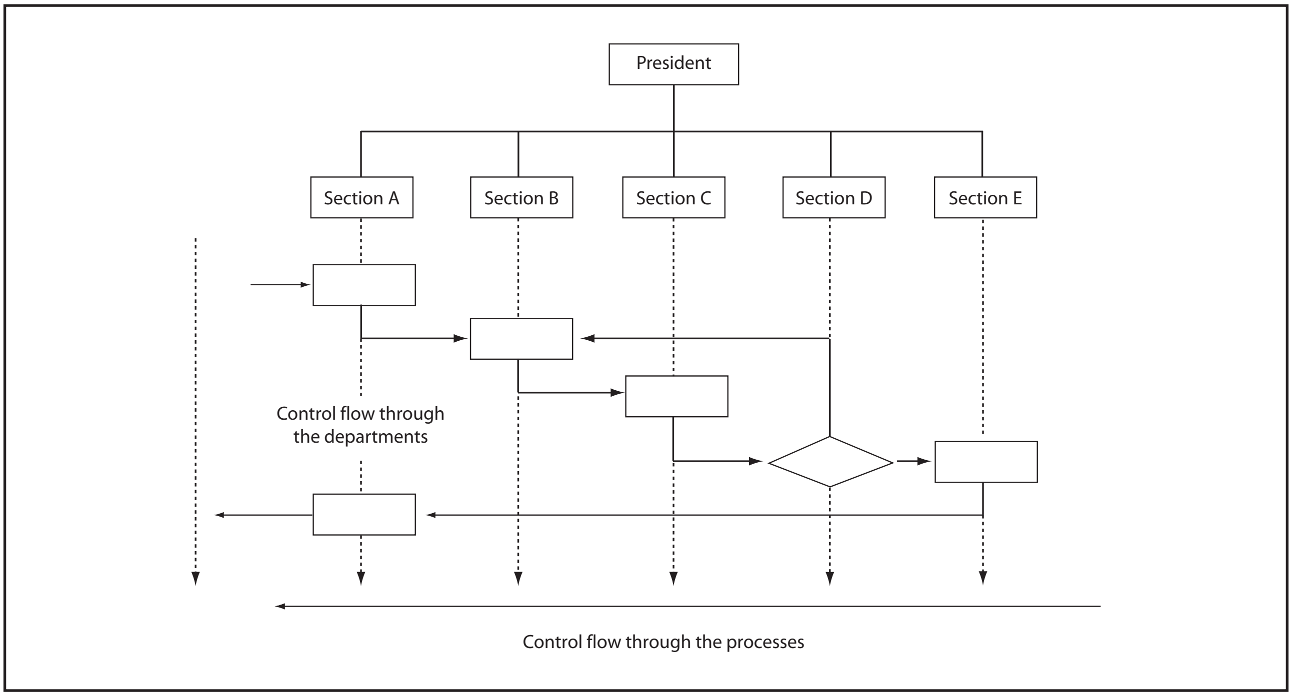



**FIGURE 2** Control flow in functional structures and in structures for process.

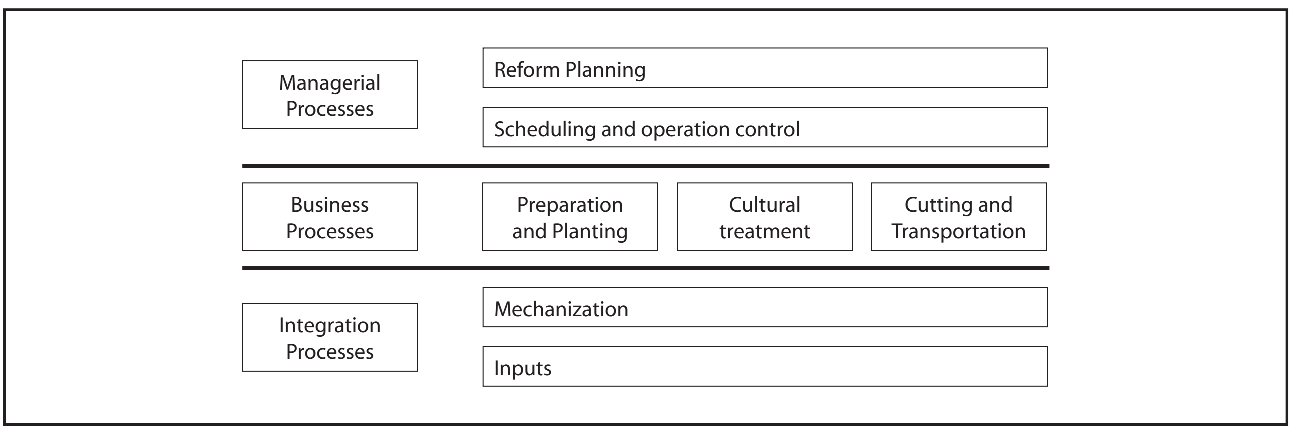



**FIGURE 3** Processes in the agricultural management.

the *Manufacturing Resource Planning* – MRP. These systems extended their inputs to control activities (purchase, storage, sales, marketing), including work and equipment – MRP to MRP II (SLACK *et al.*, 1997; GAITHER and FRAZIER, 2002; CORRÊA and CORRÊA, 2004). And since the 1990s started to expand to the whole organization, integrating all functions e.g. industrial production, human resources, finances and relations with suppliers and clients – the ERP's – Enterprise Resource Planning (Figure 4).

In Brazil, the market of these integrated packages are controlled by two large foreign companies – **SAP** (+ TriversityDiversity), whose clients include Cosan, São Martinho, Zilor, Dreyfus, Itamarati, Batatais, Santa Cruz; and **Oracle** (+Peoplesoft+J D Edwards), whose clients include Nova América, Farias); and a Brazilian company – **TOTVS** (Microsiga + Logocenter + RM + Datasul + Meya + Informenge). Some mills use ERP's developed internally, as the case of Santa Elisa (Linux platform). Others involve other companies as the

**TABLE 4** Steps of the transition for process management models.

| | Step A | Step B | Step C | Step D | Step E |
|---|---|---|---|---|---|
| **Situation** | Process/es, what process/es? | The organization identifies its processes. | The organization improve its processes. | The organization defines responsible for processes and use them as basis for allocation of resources. | The organization was designed by the logic of its essential processes. |
| **Main characteristics** | • The organization did not pay attention to the idea of process and its potential.<br>• There is only perception of the manufacture process. | • The focus of improvement effort is still in the functions.<br>• The processes are fit in the functional structure. | • The organization still rationalizes by functions, even if knows well its processes.<br>• The authority still resides in the vertical units. | • The organizations begin to obtain results of emphasis in processes.<br>• There is a level of disagreement between the functional structure and the processes. | • Functional areas practically do not exist.<br>• The goals and metrics are defined for the processes. |
| **Possibilities of improvements and gains** | Limited and related to production process. | Correlate to the treatment of bottlenecks in punctual aspects. | Correlate to the rationalization of activities in the essential processes. | Improve the isolated process management and the integration with the support processes. | Correlate to the integrated management of the essential processes. |

*Source*: GONÇALVES (2002).


**FIGURE 4** Functions Integration and processes of the company.

case of IFS, with clients *such as* Grupo Naoun, Agrovale, and Corona.

The CIO of Grupo São Martinho, Joaquim Paulo, in the Forum SAP 2006, presented an investment of R$ 12 million for implementation a SAP which led to a cost reduction of R$ 23 million.year[1]. He also highlighted that the number of positions fell from 800 to 90, suppliers from 1,500 to 900, product purchase cycle from 22 days to 4 and closing accountant from 20 days to 5.

According to data from International Data Corporation, the Brazilian IT agroindustry Market was estimated in US$ 180 million in 2006; its main deficiency includes adoption of management software (ERP) focusing on logistics, finance, purchase and storage management, soil mapping system and decision-making support in planting and harvesting processes. In the article "The second age of ERP" (Computerworld), the editors state that ERP companies will seek to "verticalize their systems", specializing in some sectors – agribusiness, for instance. In addition, the ERP's will seek to "communicate in a transparent manner with tools like Customer Relationship Management – CRM, and Business Intelligence – BI, besides, of course, being ready to support applications and new business models in the web".

## MANAGEMENT APPLICATIONS IN AGRICULTURE

### Agricultural management consultancies and applications aimed at sugarcane production

Although large management consultancies and IT integrated solutions are specializing, each department they verticalize e.g. agribusiness, the service they provide is normally complemented by other specialized consultancies with more experience, be it by mergers, partnerships or independent service providers, also appealing to the mills.

Some of these specialized consultancies do not have IT solutions, concentrating instead in carrying out studies (i.e. business plans for expansion or new mills, *benchmark*); in the creation and implementation of working methods (i.e. organization of production processes, structuring of special units of crop management, programming routines, budget control of operations), and in supporting teams. Some of them include IDEA (<www.ideaonline.com.br>), and Chaves Planejamento e Consultoria (<www.chavesconsultoria.com.br>), both based in Ribeirão Preto and the CANAPLAN (<www.canaplan.com.br>) in Piracicaba.

Adopting the same principle of process management of integrated packages (ERP) but with specialized modules of management support in sugarcane production, domestic companies have also produced and commercialized their own systems. Among them, is **Próxima** (www.proxima.agr.br) of Assis, which according its website has 115 clients in the sugarcane industry, with 5,000 users of its software, representing 45% of Brazilian sugarcane production. Próxima charges the mill customers between 0.5% and 1.8% of annual revenue for IT support.

Others include, **GATec** (<www.gatec.com.br>), based in Piracicaba, with more than 60 major clients (mills and distilleries); **UniSoma** (<www.unisoma.com>), based in Campinas; **SoftFacil** (<www.softfacil.com.br>) in Ribeirão Preto; **CHB** (<www.chb.com.br>) of Franca; or **PROCENGE** (<www.procenge.com.br>), based in Recife. As large multinational companies are entering this IT market, their applications need to be compatible with the Brazilian market, and thus some of them have established partnerships, or even in some cases taken over as the case of Próxima, by Data Sul, facilitating the verticalization. Other groups e.g. **Agrisoft** (<www.agrisoft.com.br>) of Curitiba, focuses mostly on suppliers, adopting a functional structure for its modules.

Specialized agricultural modules help to support tactical management in harvesting and logistics of sugarcane transportation, in addition to operational schedule support and control of activities, resources and costs of several operations (preparation, planting, harvesting, loading and hauling). Mechanized resources have a specific module, given its economic importance, combining machinery and maintenances activities e.g. *Assiste* – <www.assiste.com.br>, based in Piracicaba, focuses specifically on these modules.

Most of tactical management modules incorporate numeric techniques to optimize activities, using linear, integer, non-linear, dynamic or by restrictions programming, combinatorial algorithms, metaheuristic and intelligent systems (CALIARI, 2001; CALIARI *et al.*; 2004, MARQUES, 2006; HAHN, 1994; GRISOTTO, 1995; BANCHI, 1989; IANNONI, 2000; LOPES, 1995; BARATA, 1992; FLORENTINO, 2005). The difficulty in adapting these techniques has stimulated the creation of companies that deal specifically with such techniques of which a good example is iLab (<www.ilab.com.br>), based in Ribeirão Preto, or (Guarani) and GAPSO (<www.gapso.com.br>), located in Rio de Janeiro.

## GEO-TECHNOLOGY APPLICATIONS

### Remote Sensing (RS), Geographic Information System (SIG), and Global Positioning System (GPS)

New possibilities are emerging as a result of technology advances in digital images of the Earth surface with space resolutions, time frequencies and spectral bands for agricultural use – the satellite and optical sensors – and technologies for handling these images, integrated to the database – the geographical information systems – SIG. Among the most widely used in Brazil ArcGIS of the North American ERSI, the Idrisi of North American Clark Labs, and Spring of Brazilian INPE.

Although aerial pictures (photos), obtained by flying over the interested areas, generate appropriate images for agricultural applications, high costs prevent their utilization in small scale or to generate weekly or monthly time series.

The satellite registers image pixels; the most common used today in agriculture is measured in an area of 30 per 30 meters, the lowest information unit that the satellite captures. There are now more advanced models, not used yet in this activity, which register up to 60 per 60 centimeters (*Revista AlCOOLbras*, n. 95, 2005). In 2000 an image of the Landsat satellite cost up to R$ 2,000 but today it can be freely available.

Data can be both sold and disclosed via internet. The National Institute for Space Research – INPE, recently implemented free distribution of images obtained by the Sino-Brazilian (Brazil-China) satellite – the CBERS. This was offered to Brazil as the country is an important user of this technology (*Revista ALCOOLbras* n. 104, 2006).

Perhaps the biggest initial impact of this technology has been to view its own images and generate detailed maps with information of different sugarcane production areas (sections, farms, sectors, blocks etc.), which up to now were exclusively stored in big tables consisting of thousands of records and fields databases.

However, the most innovative applications are on sugarcane crop management, by means of time series of these images. With a frequent interpretation of the images, monitoring identifies any problem much easer (i.e. incidence of pests and diseases, failure in preparation and planting). Data from these images allow to identify more precisely yield estimates (i.e. errors dropped by 15% to 20%), providing the best support for harvesting, loading and hauling logistics (MACHADO *et al.*, 2002; RUDORFF, 1985; PICOLI, 2006).

Another application of this technology is pre-mapping of soils, which allows a better space distribution in greater detailed of soil sampling. For example with satellite images it is possible to differentiate soil classes and quantify some of its components – clay, iron, silt, organic matter (DEMATTÊ *et al.*, 2004; DEMATTÊ *et al.*, 2005).

The incorporation of SIG modules occurs, both in IT and large companies, by integrating generic ERP + generic SIG, as example of the SIG or ERSI + ERP of SAP of PIMS-SIG of Próxima (Datasul), using the TerraLib of INPE.

Later, the integration of these technologies with GPS, which allow to locate mobile resources (tractors, harvesting machines, sugarcane transporting trucks and peoples), opened up other management possibilities for management applications to precision agriculture.

FieldStar (AGCO) and AMS (John Deere) are example of the use of precision agriculture in machines, integrating SIG and GPS. The first provides georeferenced maps of the area to be worked by the machinery and the second reports periodically the machine position in this map, orienting, for example, route corrections (navigations systems

– light bars and DGPS) for planting or application of fertilizers with variable taxes (flow controller with GPS incorporated).

With the advent of automation of tractors and sugarcane harvesters, the GPS' signal needed be corrected. This correction is also made by remote control, prevailing the RTK standard (Real Time Kinematics). The plant needs to distribute this signal through radio or some other form of wireless that generate signals in a station with a stationary antenna. What is hoped is that in the near future signals can be generated and make more widely available. The IBGE already works with this option, although in an experimental scale, distributing differential correction RTK standard through the internet. The wireless communication at field level, with good data transfer rates is a necessity and should be available in internationally standard form.

## APPLICATIONS IN TELECOMMUNICATIONS

### From field records to mobile phones

Communication has always been an important aspect for tactical-operational level of agricultural management. The more difficult part was "bidirectional" (decision maker-operator) with the purpose to increase efficiency (i.e. avoiding time-wasting) to increase the effectiveness, mainly readjusting scheduling activity and operations in a timely manner.

Traditionally, the operations were reported in field spreadsheets by machine operators or by keepers (field work inspectors), and then sent for typing and validation, and later on for processing and management reporting, and consisting basically of average performance for comparison at the end of the harvest. The whole process would normally take 5 to 7 days.

Two changes brought together operational and tactical levels. The first were the sensors attached to machines (integrated to PDA's – Personal Digital Assistant) that allowed controlling the equipment conditions (oil temperature, and speed) or operational results (worked area, or volume of cane harvested), operational time's e.g. "reasons for stopping". This information was later "downloaded" into computers (IrDA, BlueTooth), which allows to bypass typing, and thus minimizing errors and shortening the time to generate information to support decision-making.

The second change was the communication systems, initially through radio frequency – RF, and more recently also through GPRS – General Packet Radio Service[8], via mobile phones. In the first case it was possible to accelerate the use of field data, inserted in the PDAs which became available as it was generated; and the second case made possible the dissemination of bidirectional communication, improving and extending radios, thus allowing direct access to information on activities directly managed or performed by means of Web applications. Advances in communication, the PDAs (or handhelds, palmtops), evolved rapidly, acquiring new features e.g. use of mobile phones, wireless internet access, (or handhelds, palmtops) and supports Web applications, besides the possibility to incorporate GPS.

Broadband technologies (GSM and CDMA) of the current generation of mobile networks have a low range in areas with low number or scattered population, a common feature in many rural regions, and this results in poor signal quality or none at all. As stated by MOLIN (1985), to overcome these limitations, some companies have developed data collection systems that use radiofrequency to transfer between components e.g. between field equipment and the trucks. The data typed by operators, or collected by sensors, in machines are transferred to trucks that, when reaching the plant, perform a new transfer by radiofrequency, downloading this data to the central database. This represents a relatively simple solution that generates useful information on CCT with just a few hours of delay. New generation of broadband technologies (WCDMA/3G e WiMax) promise to overcome current limitations.

[8] The GPRS technology reaches velocities of up to 115 kpbs, making it viable the high speed internet access and other communication systems, besides supporting a wide range of bands.

These developments, providing greater communication agility, allows decision makers to prepare reports with just a few hours "delay" after carrying out operations, while at the same time operators and inspectors can receive frequent information related to their operations more frequently, thus minimizing stopping time and better redirecting of operations in case of unexpected events.

An example of company specialization in development and implementation of portable devices, one could mention Simova e-Logicon (<www.simova.com.br>), based in São José dos Campos. The BoB – Boletins on Board – is an automatic system of agricultural records, fed by cell phone that allows monitoring in real time, through the internet, of all machines in operation and to interact with the operators[9]. The system is being implemented in the mills of the *Grupo Equipav*, with has close to 450 cell phones, covering an area of 100,000 ha of sugarcane crop and generated an economy of R$ 1 million to the group, according to its IT manager[10].

The *SIG Logística* of Enalta (<www.enalta.com.br>), located in São Carlos, specializes in sugarcane hauling logistics from the field to the mill. Fed by information, in real time, of the fleet location, harvesting and milling conditions of the plant, the trucks receive guidance on what to do, both at the exit of the plant, after unloading or during this operation, if some unforeseen event happens.

## FINAL CONSIDERATIONS

The Workshop, mentioned at the beginning, had four panels, each one dealing with one of the organizational and technological innovations presented in this chapter. Each panel was made up of representatives from research institutions, service providers and mills.

Generally, research institutions approved the "state of art" practices and the technology management stated in the Terms of Reference; service providers put forward their solutions while mill representatives described the current situation. Despite the Terms of Reference, nothing was said with regard to the medium to long terms technological situation or the bottlenecks needed to overcome to further its development. In the short term, it was expected that service providers will draw attention to the "necessity of adopting modern management solutions", be it on organizational practices or in management technological terms.

Management models based on processes are relatively new and the electronics embedded in computers, sensors, actuators, networks, telephones, GPSR etc., are continuously improving and becoming cheaper, allowing the development and the integration of support systems in decision-making. In some cases, access to data with frequency and reliability is not a technical problem; the question is to what extent it is possible to transform data into useful information for the decision maker and what kind of rewards will be available for investment in management systems.

It should be emphasized that the use of an information system is closely tied up to the business culture. Thus, information and support systems in decision-making that fail to meet the "managerial spirit of the organization", even if technically qualified, can result in a serious failure.

Technological production is prolific but the mills and suppliers need to have access to it (specialy the samall ones), and reliable information from producers/sellers of this thechnology, regarding investment return, should be available.

As a way of promoting and adopting technology management, the sugarcane chain seems to need information that assesses the cost-benefit relation of these solutions. Such assessment need to be carried out taking into account the diversified profile of potential users, so that it can provide appropriate solutions to each plant or supplier. Lack of assessment creates a vicious circle where innovative organizations do not show interest in disclosing their results for fear of competition. This makes it harder for new users to join the market and compete with established companies in this area on the same basis.

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9 *Revista Fator, agronegócios,* 09.20.2007.

10 Google News. Cellular Networks increase profit in sugarcane farms. 27.03.2008.

It should also be recognized that the lack of technology assessment may be interpreted as a consequence of the sugarcane industry cultural characteristic, once the industry has sufficient organization by means of it associations to mobilize efforts for an activity such as this. An alternative is the benchmark carried out by the IDEA group and, more recently, by CTC, besides management quality awards, which exemplifies "good management practices."

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