From bagasse to innovation

In the midst of an industry crisis, companies are investing in technology to increase ethanol production

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In early February, ETH Bioenergia, which was founded in 2007 by the Odebrecht Organization, changed its name to Odebrecht Agroindustrial. The company also announced that it would make investments to extract 30% more volume from the sugarcane processed in 2012/2013 and to produce two billion liters of ethanol—equal to 8.6% of Brazil's current annual production of 23 billion liters. The R$1 billion investment will help to expand the growing area and support research into sugarcane varieties and new ethanol-production processes. To achieve these goals, the Odebrecht Agroindustrial innovation unit, which was created in 2010, must partner with universities and research centers, such as the Campinas Institute of Agronomy (IAC).

"We are building our innovation strategy at a time when Brazil is experiencing a sugarcane crisis," says Carlos Calmanovici, Director of Innovation and Technology for Odebrecht Agroindustrial. Odebrecht is one of several large companies, including Syngenta, Monsanto and Granbio, that have recently increased their investments toward research using plant-breeding techniques to obtain new sugarcane varieties or developing alternative ethanol-production methods using the leftover bagasse from sugarcane plants.

A combination of several factors explains the not-so-sweet deceleration of the sugar-energy industry since 2008, including the international credit crisis, weather events in three consecutive years from 2009 to 2011, and the lack of adjustments in the price of gasoline. However, a gap separates the sugarcane-production crisis from the status of research in the industry. The difference, says Calmanovici, is that research is based on a long-term perspective. One example of this strategic vision is the cooperation agreement that the company signed with FAPESP in 2011, which has resulted in 11 joint projects with universities in São Paulo State, such as the University of São Paulo (USP), the University of Campinas (Unicamp) and the Federal University of São Carlos (UFSCar). These projects received R$20 million in funding, half disbursed by FAPESP and half provided by Odebrecht Agroindustrial. Many of these projects were initiated last year and involve developmental research on insect-resistant transgenic sugarcane and on identifying and selecting plants whose genotypes (genetic makeup) are suitable for the agroecological conditions of the Pontal do Paranapanema region, where sugarcane productivity remains low.


SYNGENTA

Strategies to address the crisis

Companies are betting on new technological alternatives to increase sugarcane production

SYNGENTA
Has developed the sugarcane variety Cana Plene, which has resistance to some sugarcane pests and eliminates the need for nursery areas and for the use of heavy harvesting machinery, thereby preserving the soil, according to the company.

CENTRO DE TECNOLOGIA CANAVIEIRA (CTC)
Has mapped low-productivity areas and is developing sugarcane varieties for these regions with a maximum time-to-market of eight years (a process that once required 12–14 years).

GRANBIO
Has constructed an experimental plant where second-generation ethanol production will begin this year and has developed a new sugarcane variety called Cana Vertix, which is resistant to pests and diseases and has a high fiber content.

MONSANTO
Has developed new sugarcane varieties that are adapted to mechanized harvesting and have high germination rates in less-favorable planting environments.

ODEBRECHT AGROINDUSTRIAL
Has funded research on new sugarcane varieties, including transgenics, to boost ethanol production and expand cultivable areas.

NOVOZYMES
Has developed enzymes capable of breaking down the lignin present in the pulp cells of bagasse to produce second-generation ethanol.

A seedling of a new sugarcane variety is manipulated in Syngenta's laboratory

Ups and downs of sugarcane in Brazil

Timeline of the domestic sugar-energy industry

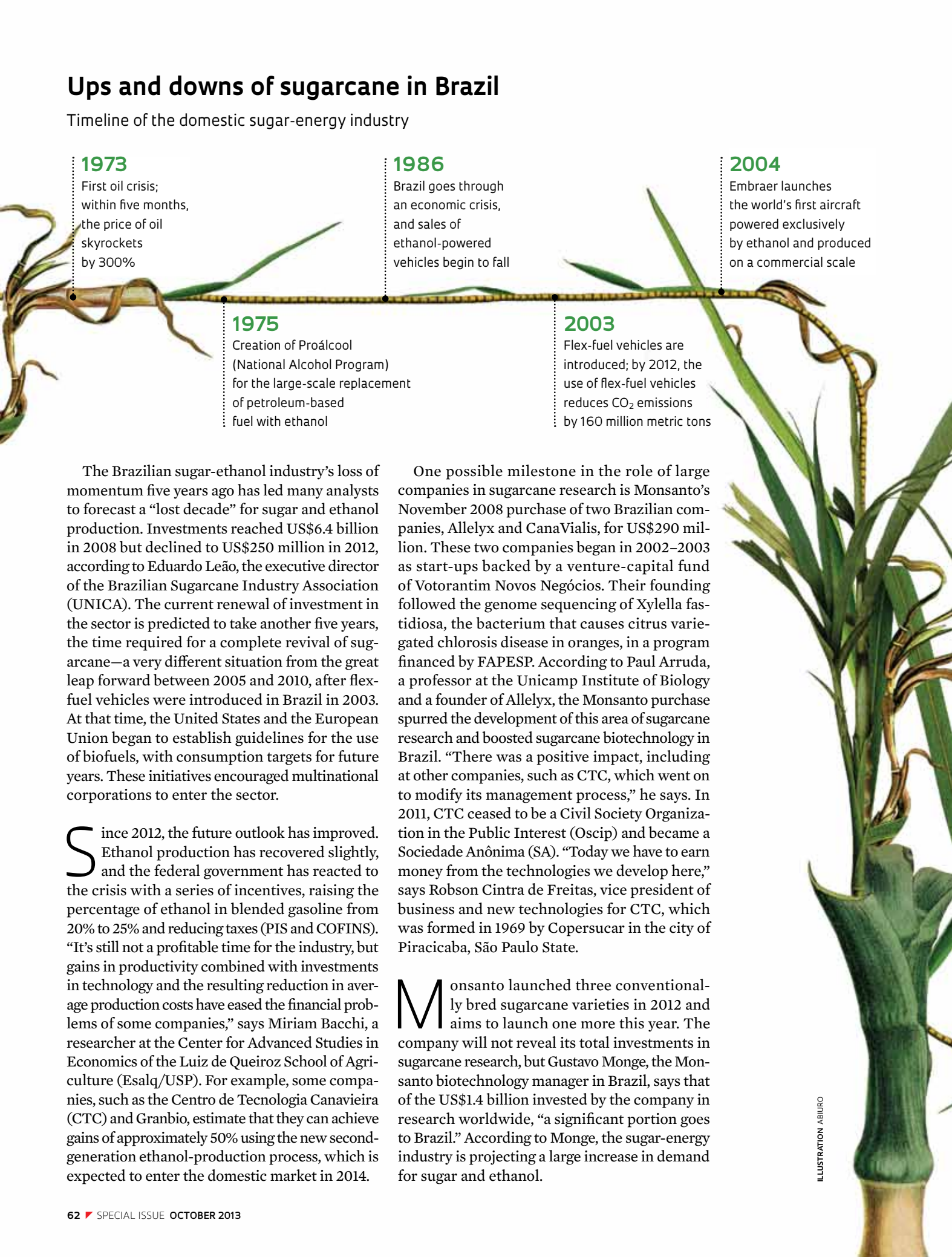
1973
First oil crisis; within five months, the price of oil skyrockets by 300%

1975
Creation of Proálcool (National Alcohol Program) for the large-scale replacement of petroleum-based fuel with ethanol

1986
Brazil goes through an economic crisis, and sales of ethanol-powered vehicles begin to fall

2003
Flex-fuel vehicles are introduced; by 2012, the use of flex-fuel vehicles reduces CO_2 emissions by 160 million metric tons

2004
Embraer launches the world's first aircraft powered exclusively by ethanol and produced on a commercial scale



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The Brazilian sugar-ethanol industry's loss of momentum five years ago has led many analysts to forecast a "lost decade" for sugar and ethanol production. Investments reached US$6.4 billion in 2008 but declined to US$250 million in 2012, according to Eduardo Leão, the executive director of the Brazilian Sugarcane Industry Association (UNICA). The current renewal of investment in the sector is predicted to take another five years, the time required for a complete revival of sugarcane—a very different situation from the great leap forward between 2005 and 2010, after flex-fuel vehicles were introduced in Brazil in 2003. At that time, the United States and the European Union began to establish guidelines for the use of biofuels, with consumption targets for future years. These initiatives encouraged multinational corporations to enter the sector.

Since 2012, the future outlook has improved. Ethanol production has recovered slightly, and the federal government has reacted to the crisis with a series of incentives, raising the percentage of ethanol in blended gasoline from 20% to 25% and reducing taxes (PIS and COFINS). "It's still not a profitable time for the industry, but gains in productivity combined with investments in technology and the resulting reduction in average production costs have eased the financial problems of some companies," says Miriam Bacchi, a researcher at the Center for Advanced Studies in Economics of the Luiz de Queiroz School of Agriculture (Esalq/USP). For example, some companies, such as the Centro de Tecnologia Canavieira (CTC) and Granbio, estimate that they can achieve gains of approximately 50% using the new second-generation ethanol-production process, which is expected to enter the domestic market in 2014.

One possible milestone in the role of large companies in sugarcane research is Monsanto's November 2008 purchase of two Brazilian companies, Allelyx and CanaVialis, for US$290 million. These two companies began in 2002–2003 as start-ups backed by a venture-capital fund of Votorantim Novos Negócios. Their founding followed the genome sequencing of Xylella fastidiosa, the bacterium that causes citrus variegated chlorosis disease in oranges, in a program financed by FAPESP. According to Paul Arruda, a professor at the Unicamp Institute of Biology and a founder of Allelyx, the Monsanto purchase spurred the development of this area of sugarcane research and boosted sugarcane biotechnology in Brazil. "There was a positive impact, including at other companies, such as CTC, which went on to modify its management process," he says. In 2011, CTC ceased to be a Civil Society Organization in the Public Interest (Oscip) and became a Sociedade Anônima (SA). "Today we have to earn money from the technologies we develop here," says Robson Cintra de Freitas, vice president of business and new technologies for CTC, which was formed in 1969 by Copersucar in the city of Piracicaba, São Paulo State.

Monsanto launched three conventionally bred sugarcane varieties in 2012 and aims to launch one more this year. The company will not reveal its total investments in sugarcane research, but Gustavo Monge, the Monsanto biotechnology manager in Brazil, says that of the US$1.4 billion invested by the company in research worldwide, "a significant portion goes to Brazil." According to Monge, the sugar-energy industry is projecting a large increase in demand for sugar and ethanol.

EDUARDO CESAR

Sugarcane seedlings are prepared in CTC's laboratory in Piracicaba (*left*) before being transferred to the greenhouse (*right*) and then to nurseries at the production facility

"In the research field, I cannot imagine biotechnology firms being affected either positively or negatively by the crisis because decisions are long-term, and they look for a market situation in which ethanol competitiveness increases as a result of innovation," says André Nassar, an economist with the Agroicone consulting firm. According to José Maria da Silveira, a professor at the Unicamp Institute of Economics, "the increase in applied research is stimulated by public institutions partnering with the private sector." As an example, he cites the FAPESP Program for Research on Bioenergy (BIOEN), which began in 2008 and now has 12 partner companies, including Odebrecht, Dedini, Oxiteno and Braskem. "There has been an evolution in the number of partnerships between the program and companies seeking increases both in conventional breeding and in the transgenic route," says Glaucia Souza Mendes, a professor at the USP Institute of Chemistry and a BIOEN coordinator.

Another institutional measure that favors research is the requirement that the harvest be fully mechanized in São Paulo State—the heart of sugarcane production in Brazil, accounting for 52% of national production, according to Companhia Nacional de Abastecimento (Conab), a state-owned company linked to the Ministry of Agriculture. Mechanization ultimately requires innovative technologies in equipment and in new sugarcane varieties that are better suited to the process. Some of the varieties produced by Monsanto, for example, are readily adaptable to mechanical harvesting. In 2007, according to the state government, São Paulo State eliminated the burning of 5.53 million hectares and thus prevented more than 20.6 million tons of pollutants from being released into the atmosphere.

In its new phase, CTC has contributed an important technological innovation in the field. The company has been able to reduce the time-to-market for new sugarcane varieties developed in its breeding program by at least six years. Until a few years ago, the time required to transfer a new variety from the laboratory to the marketplace, which involves a series of tests and cross-

2005
First new-energy auction; today, electricity produced from bagasse supplies more than 2% of Brazil's consumption

2007
Agro-Environmental Protocol of São Paulo State foresees an end to the burning of cane straw

2008
Launch of BIOEN-FAPESP; height of the credit crisis in the United States

2010
The United States classifies sugarcane ethanol as an advanced biofuel; the Brazilian Bioethanol Science and Technology Laboratory (CTBE) is created

2013
Reinstatement of 25% mixture of anhydrous ethanol in gasoline; launch of federal-government incentives for the sugar-energy industry

breedings, was 12 to 14 years; today, only 8 years are needed, says Mark Casagrande, CTC's manager of product development.

Since 2007, CTC has focused its attention on second-generation ethanol. Between July and August of 2013, it will begin to construct a demonstration plant at Usina São Manoel with the capacity to produce three million liters of ethanol before moving on to the industrial stage. In 2008, CTC patented the process that it had developed to obtain cellulosic ethanol from sugarcane because its process represented a strategic difference from the methods used by other companies in the research race for second-generation ethanol in Brazil. The process of enzymatic hydrolysis of the cellulose present in the bagasse and straw will be fully integrated into the existing structure of the production plant. In addition to reducing costs, this integration provides an alternative solution to the problem of excess fermentation and distillation capacity, two sectors of the plant that usually have approximately 30% downtime, by giving the plant greater flexibility to alternate between sugar and ethanol production. "If second-generation ethanol is added in a plant, it is possible to use this potential to obtain a cheaper fuel," says Freitas. Earlier this year, the BNDES-Finep Joint Plan to Support Industrial Technological Innovation in the Sugar-Energy and Sugar-Chemical Sectors (Paiss) signed its first contract with a company (CTC), which received a credit of R$227 million from the Brazilian Innovation Agency (Finep) out of a total of R$2 billion that will be allocated to projects by mid-year.

Granbio, a Brazilian company founded in 2011, also sees new horizons for second-generation ethanol. This year, its synthetic-biotechnology research center, located in the Techno Park complex in the city of Campinas, opened for the development of Brazilian yeasts used in industrial fermentation. In May, the company opened a second-generation experimental station in Alagoas State with an investment of R$10 million. The company's goal is to begin cellulosic-ethanol manufacturing by February 2014 at an investment of R$350 million, with an estimated production of approximately 82 million liters of second-generation ethanol, representing a 20% increase in biofuels production in Alagoas.

The new Granbio sugarcane variety, known as Cana Vertix, is being developed by crossing ancestral sugarcane types with commercial hybrids. "We will have a more robust sugarcane, more resistant to pests and diseases, greater longevity, a higher fiber content and greater productivity than conventional plants," says Alan Hiltner, executive vice president of the company. Gonçalo Pereira, a Unicamp researcher and the company's vice president of technology, says that the new sugarcane variety will be used only for Granbio's own consumption. "The efficient photosynthesis of Cana Vertix will be reflected in the cost of the raw material. In the industry, the leader of the pack is the company with cheap and efficient sugarcane," he says. By the end of 2013, 200,000 seedlings will be planted using seeds from Brazilian and worldwide germplasm (seeds and cells) banks. Currently, IAC and the Inter-university Network for the Development of the Sugar-Energy Industry (Ridesa) are performing the cross-breeding. In 2014, this work will also be performed at the Alagoas experimental station. Hiltner notes that one reason to invest in second-generation ethanol from bagasse and cane straw is the fact that the U.S. market rewards the use of cellulosic ethanol, particularly in California, where there is an additional reward per metric ton of captured carbon.

"There has been an evolution in the number of partnerships between BIOEN-FAPESP and businesses," says Mendes

The various initiatives for second-generation ethanol have impacted the supply chain, which includes the suppliers of the enzymes

PHOTOS 1 SYNGENTA 2 MICHEL RIOS

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used to break down the lignin and hemicellulose of sugarcane cells to yield pulp and then glucose, thus enabling ethanol production via sugar fermentation. In 2007, for example, the Danish multinational corporation Novozymes, which was founded in 1923, entered into its first commercial partnership to develop enzymes for ethanol production (with CTC).

1 Syngenta's Research Center in Itápolis, São Paulo, where the company multiplies genetic material.
2 Sugarcane greenhouse at Granbio's new experimental station in Alagoas.


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Novozymes began supplying enzymes to Petrobras, which also has a research program in second-generation ethanol, in 2010 and entered into an agreement with Granbio in 2012. According to Pedro Fernandes, the president of Novozymes for Latin America, the sugar-energy industry crisis has affected the company because customers have reduced their demands for production and investments. However, research has continued apace. "Crises always come and go, but research does not. If we stopped research today, a recovery from the setback would last longer than the crisis," he said. Novozymes invests US$300 million in R & D across its research facilities worldwide, including enzyme research for ethanol production in Brazil. The Latin American division of the company represents 10% of Novozymes' global revenue, which was $2 billion in 2012. Today, Novozymes employs 11 professionals working directly in research in Brazil, two with PhDs and the others with advanced degrees. The company has also formed partnership with the Federal University of Paraná (UFPR) to perform enzyme testing.

"Paralyzed research takes longer to recover from than the crisis itself," says Fernandes

Another company that has become more involved in sugarcane research is the Swiss multinational corporation Syngenta. In 2006, this company's share of the sugarcane market was marginal, consisting only of sales of chemical pesticides. Beginning in 2008, the company shifted toward the adoption of new technological strategies to increase sugarcane planting. For example, a bio-factory facility to perform plant-breeding procedures began construction in 2012. "The demand for sugarcane in Brazil by 2020 will be approximately 1.1 billion metric tons. The key to success for ethanol production is to increase productivity, which also requires research," says Adriano Vilas Boas, Syngenta's global director of sugarcane. UNICA estimates that ethanol production from the 2013/2014 crop will be 20% higher than in the previous year.

Today, Syngenta has established three pillars to support sugarcane research. The first is to multiply genetic material, which is done in the city of Itápolis, São Paulo State. At Itápolis, disease-free plants are generated by multiplying genetic material, thereby ensuring healthy plant materials because sugarcane has a high risk of contracting disease during breeding. "So we are multiplying clones of the same matrix in a controlled manner," says Vilas Boas. To obtain thousands of samples, the sugarcane is managed in the greenhouse environment, and the samples are multiplied, preserving their DNA, so that they can be directly planted in field nurseries. Biotechnology research aiming to increase the ability to develop genetically modified sugarcane varieties is now being performed at the company's research stations in Brazil. Syngenta is investing more than $1.4 billion in research and development worldwide but has not disclosed its budget for sugarcane in Brazil. Today, it employs more than 100 agronomists working on sugarcane and developing technology in the field, including a team dedicated exclusively to transgenic research. Its partnerships with universities include the Universidade Estadual Paulista (Unesp) and Esalq/USP, which help to validate the technologies, and IAC, which participates in a joint project to improve sugarcane breeding and processing methodologies. ■