Sugarcane in Brazil Current technologic stage and perspectives[1]

Tarcizio Goes[2]
Renner Marra[3]
Marlene de Araújo[4]
Eliseu Alves[5]
Mirian Oliveira de Souza[6]

Abstract – This article aims at analyzing the sugarcane culture in Brazil, showing the current agricultural and industrial development stage of the sugar-alcohol industry and how important this culture has become. It discusses its technologic evolution and the technologies that are being developed in the fields of genetic improvement and new cultural practices, and it aims at estimating the benefits that can be obtained in the next few years with the use of new varieties with specific characteristics, proper varietal management and modern cultural practices. By using data from IBGE (the Brazilian Institute of Geography and Statistics), the productivity of Brazil and of the North, Northeast, South-East, Middle-West and South regions of the country were estimated based on the genetic potential from new varieties and on the use of new cultural practices. Using information from the results of the agricultural research, it was possible to conclude that a significant raise of sugarcane productivity levels in Brazil, due to genetic improvement, is bound to happen in the next few years.

Keywords: sugarcane, ethanol and sugar.

Cana-de-açúcar no Brasil – atual estágio tecnológico e perspectivas

Resumo – Este artigo tem como objetivo analisar a cultura da cana-de-açúcar no Brasil, mostrar o atual estádio de desenvolvimento agrícola e industrial do setor sucroalcooleiro e a importância que essa cultura vem assumindo. Discorre sobre sua evolução tecnológica e sobre as tecnologias que estão sendo geradas, no campo do melhoramento genético e da utilização de novas práticas culturais, e procura estimar os benefícios que poderão ser obtidos nos próximos anos com a utilização de novas variedades com características específicas, manejo varietal adequado e modernas práticas culturais. Utilizando-se de dados do IBGE, estimou-se a produtividade do Brasil nas regiões Norte, Nordeste, Sudeste, Centro-Oeste e Sul, com base no potencial genético de novas variedades e na utilização de novas práticas culturais. Utilizando informações sobre resultados de pesquisa agropecuária, conclui que ocorrerá, nos próximos anos, por causa do melhoramento genético e da elevação significativa dos níveis de produtividade da cana-de-açúcar no Brasil.

Palavras-chave: açúcar, álcool e cana-de-açúcar.

[1] Original recebido em 11/11/2010 e aprovado em 20/12/2010.
[2] Researcher at Embrapa/SGE, Master in Agricultural Economics. E-mail: tarcizio.goes@embrapa.br
[3] Analyst at Embrapa/SGE, economist. E-mail: renner.marra@embrapa.br
[4] Analyst at Embrapa/SGE, Master in Science & Technology Policy and Management and doctoral candidate. E-mail: marlene.araujo@embrapa.br
[5] Researcher at Embrapa, Presidency Advisor, Ph. D. in Agricultural Economics. E-mail: eliseu.alves@embrapa.br
[6] Researcher at Embrapa/SGE, Master in Statistics. E-mail: mirian.souza@embrapa.br

Introduction

Within the last few years, sugarcane has become very important in Brazil's economy and in the world scenario. The sugar-alcohol industry is the most modern and competitive sector in the world. The history of sugarcane in Brazil is almost five centuries old, considering that the first Brazilian sugar mill was built in 1532.

Ever since, important advances in sugarcane cultivation and industrialization process have been made, taking the culture to a high technologic level. About 50 years ago, besides sugar, the mills started to produce ethanol. Nowadays, the bioelectricity (with highlights on the energy cogeneration process from bagasse and straw); the alcohol-chemistry with polymers production – with highlights on the green plastic, which has gone into production already in industrial scale; and the 2nd generation ethanol obtained from the hydrolysis process, which is observed in rather advanced studies, are in great evidence. Currently, the sugarcane cultivation may be part of the carbon credits commercialization, and new products and byproducts obtained from the industrial process of sugar and ethanol innovate activities in other sectors.

Method

Three dispersion measures were used to compare the productivities of the geo-economic regions of the country.

The first measure, the standard deviation, indicates how the data varied around the mean. It was calculated for each year, considering the observed productivities. The standard deviation variation, throughout the years, is small, with a slight tendency to growth: 0.09 time variable coefficient, significant by the 1% level, with weak model adjustment. It is observed that the standard deviation is the distant measure of the observations in relation to the mean.

The second distance measure in relation to the Northeast (Northeast Deviation, in the graphic) is defined as follows: for each year, the difference between the productivity of each of the three southern regions – the Middle-West, the Southeast and the South –, and the sugarcane productivity of the Northeast, are obtained. Each obtained result is squared and the three results are summed up. Afterwards, the square root of the sum is taken, resulting in the Northeast Deviation. For 24 years, the three southern regions have distanced from the Northeast, having sugarcane productivities increasing in higher rates than the ones from this region. This distance was shortened by the Northeast, but, in the last nine years, it has started to increase again.

The third measure obtains the distance for the five regions (General Deviation, in the graphic). The behavior is similar to the Northeastern, but more erratic.

For the projected average sugarcane yield analysis, projections elaborated by autoregressive integrated moving average models were used (ARIMA). Such statistical approach was implemented in the software SAS v. 9.2, via the ARIMA procedure.

Sugarcane expansion in Brazil

Since it was introduced in the country, the sugarcane has been expanding in highly significant rates. Based on a historical series with data regarding the harvested area and the production in the period from 1940 to 2010, as shown in Figures 1 and 2, the expansion rate of this culture is quite evident.

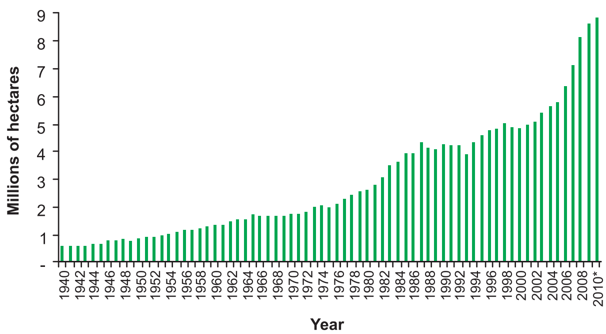

Figure 1. Sugarcane land occupation from 1940 to 2010 (millions of hectares).
* Prediction.
Source: IBGE (1990, 2003, 2010).

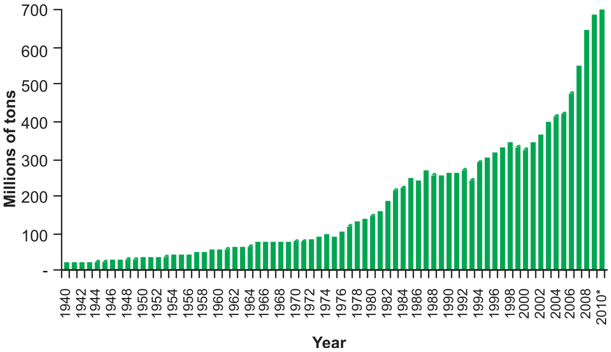

Figure 2. Population increase from 1940 to 2010 (millions of tons).
* Prediction.
Source: IBGE (1990, 2003, 2010) and Conab (2010).

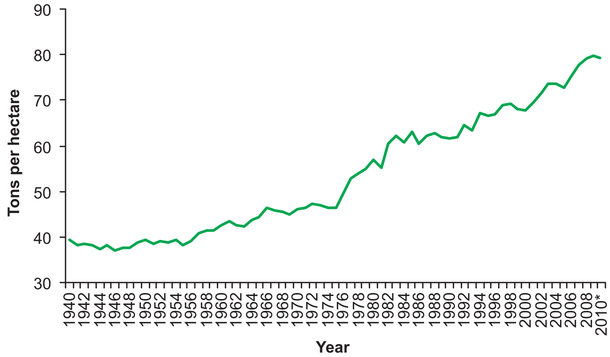

Figure 3. Average yield from 1940 to 2010 (Tons per hectare).
* Prediction.
Source: IBGE (1990, 2003, 2010) and Conab (2010).

As it can be observed, in the last ten years an escalating growth started for both the planted area and the production level, which has peaked in the period from 2006 to 2009, reaching 35% growth rates in area expansion and 43% in production volume. Figures 1 and 2 are very resembling, which makes notorious that this culture growth occurred both horizontally (occupation of new areas) and vertically (productivity levels elevation). Figure 3 shows the productivity growth of sugarcane in the period from 1940 to 2010. Currently, the average sugarcane production in Brazil is 79 tons per hectare. However, this number can still increase considerably. In proper weather and soil conditions, and by using new technologies, it is possible to produce up to 150 tons/hectare/year (LANDELL et al., 2010, p. 884-885). Research results show that the expansion process of sugarcane was concentrated in the Middle-South (over 80% of the sugarcane produced in Brazil). The highest growth rates in planted areas were registered, in the last harvests, in the states of Goiás, Mato Grosso do Sul and Minas Gerais, which are the new sugarcane borders (CONAB, 2010).

Modernization of the Sugar-Alcohol Industry Agricultural

The modernization process of the sugar-alcohol industry is based in genetic improvement and cultural practices. Thanks to the obtainment of new varieties, Brazil could increase sugarcane productivity in over 50% in the last 30 years, according to Figure 3. From the beginning of the 90's, through the Sugarcane Genome Project, the identification of the genes involved in the growth procedure, sugar content, resistance to several kinds of stress, and other characteristics to increase the commercial productivity of the culture has been made possible. According to information from the Council for Biotechnology Information (CIB), the complete sequencing of the sugarcane genome will make possible the development of new highly productive varieties that also attend other characteristics, such as drought and frost resistance, or new needs in productive and industrial management, whether for environmental or market reasons (CONSELHO DE INFORMAÇÕES SOBRE BIOLOGIA, 2009). Sugarcane genetic improvement reaches a high technologic degree today. The use of new cultural practices, planting, fertilization and other recently used systems are factors that, together with genetic improvement, increase productivity levels and competitiveness of sugarcane in Brazil.

Figure 4 shows the average sugarcane yield per geo-economic regions. As it can be observed, there was a significant productivity growth in all regions. Regarding the Southeast, Middle-West and South, which compose the

Middle-South region (in which around 80% of the sugarcane production is found in Brazil), there is a resemblance as to the productivity growth. However, there is a slight discrepancy regarding the productivity levels observed in the North and Northeast regions, a fact that has been historically evidenced due to weather and soil conditions, the use of technologies, among other factors. This productivity gap in the North and Northeast, in relation to the Middle-South, has been gradually decreasing, with chances to even lower levels in the next few years due to the technologies that are being used.

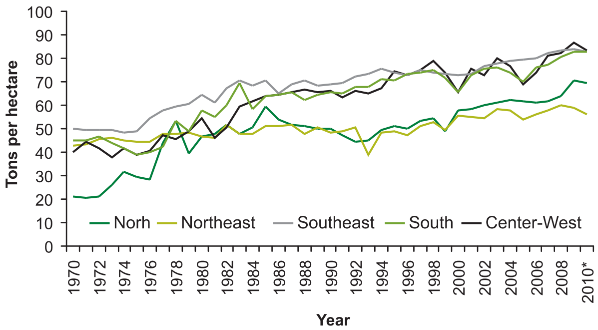

Figure 4. Sugarcane average yield evolution per geo-economic regions (Tons per hectare).
* Prediction.
Source: IBGE-PAM data 1970 to 2010 (IBGE, 2010).

In Figure 5, it is therefore concluded that the productivities are not converging in relation to the annual means (standard deviation), to the three southern regions in relation to the Northeast, and when the five regions are considered.

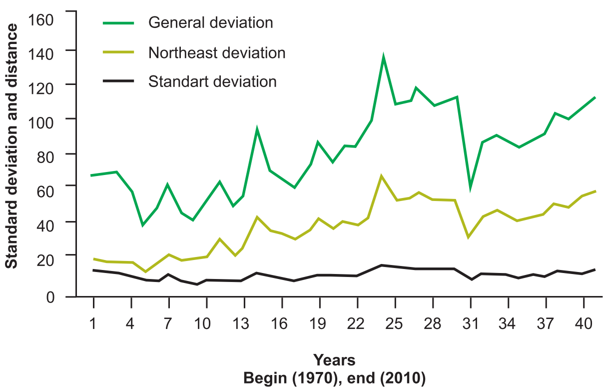

Figure 5. Standard deviation and distance of the three southern regions in relation to the Northeast.

Industrial

The sugarcane industry has reached a high technologic modernization level, presenting results as yield increase, a range of new alternatives and business opportunities represented by new products and byproducts obtained from the industrial process. The use of byproducts that have become essential raw-materials such as the bagasse, the straw, the tip and the vegetal residues of the plant, is standing out. Within this approach, there are three great utility lines for the production.

The first one is the obtainment of 2nd generation ethanol, the alcohol extracted from the cellulose using sugarcane bagasse and straw as raw material – sources of cellulose which respond to two thirds of this plant's energy. The second one is the use of byproducts which have become essential raw-materials such as the bagasse, the straw, the tip and the vegetable residues of sugarcane; and the third one is the biomass present in the sugarcane, which is, today, of great importance for bioelectricity, a segment that is in full development in Brazil with the advance of the clean and renewable alternative energy development policy.

New technologies, impacts in production and productivity

The sugarcane agro-industry is a great field for researches, starting from the agricultural area and continuing to biotechnology, sucrochemistry, ethanolchemistry, bioengineering, microbiology, among others; thus confirming that the search for new, more economically viable technologies is endless in any area of human activity. (REVISTA CANAVIEIROS, 2010, p. 52).

The technologic development of sugarcane in Brazil is based on genetic improvement or transgenic programs, which have make possible to obtain new varieties that are more productive and resistant to pests and diseases, and that have higher adaptability to several weather conditions – such as the hydrous stress typical from regions that have longer dry periods –, soil conditions and other important genetic characters. The transgenic varieties are available in Brazil since 1990, but they have not yet been released for cultivation. These genetic improvement programs have been developed by governmental institutions and private companies, sometimes by partnerships, and three great programs are responsible for almost all varieties used to produce ethanol and sugar in Brazil. The programs belong to the Inter-university Network for the Development of the Sugar and Ethanol Industry (Ridesa); to the Sugarcane Technology Center (CTC); and to the Agronomic Institute of Campinas (IAC). Based on the genetic improvement work developed by these institutions, the Brazilian sugarcane productivity increased over 50% in the last 30 years (CONSELHO DE INFORMAÇÕES SOBRE BIOTECNOLOGIA, 2009). Considering the aforementioned facts, it is possible to affirm that varieties with high productivity levels used to replace other already existing varieties, related to new cultural practices, may significantly increase sugarcane productivity levels within the next 20 to 30 years, in Brazil. The most important varieties which compose the varietal census of CTC, RIDESA and IAC, and their characteristics:

Productivity and characteristics of sugarcane varieties from the Inter-university Network for the Development of the Sugar and Ethanol Industry (Ridesa); the Sugarcane Technology Center (CTC); and the Agronomic Institute of Campinas (IAC).

CTC Varieties

CTC10

Productivity: over 100 t/ha.

It stands out for its very high agricultural productivity and ratoon longevity, with high sucrose content. It is recommended for harvesting from the middle of the crop, in environments with medium production potential. It presents medium fiber content, does not blossom and does not suffer from "*isoporização*[TN]" It is resistant to rust, to mosaic and to yellowing. It shows intermediary reaction to scalding, to coal and to the sugarcane borer. It has a good response to chemical maturers.

CTC11

Productivity: over 85 t/ha.

It stands out by its high productivity, quick vegetative development, straight stature, excellent sprouting and ratoon longevity. It presents high sucrose content and medium fiber content, being recommended for harvesting after the middle of the crop, in medium to high production potential environments. It rarely blossoms and slightly suffers from *isoporização* in the Middle-South conditions, and blossoms a little in the conditions of the Northeast. It is resistant to rust, scalding and yellowing. It presents intermediary reaction to coal, mosaic and sugarcane borer. It has an excellent response to chemical maturers.

CTC12

Productivity: over 80 t/ha.

Very precocious, with high sucrose content and low fiber content, straight stature and excellent harvesting condition. It is recommended for the beginning of the crop in environments with high production potential, it does not blossom and it does not suffer from *isoporização* in the Middle-South conditions. The blossoming is medium in the Northeast conditions. It is resistant to rust, scalding, coal, mosaic and yellowing. It presents intermediary reactions to sugarcane borer. It responds well to chemical maturers.

[TN] Translator's Note: This expression describes a degradation process of the sugarcane, in which the pith of the plant loses juice and sugar content, presenting large quantities of fiber. The word *"isoporização"* derives from *"isopor"*, which means "styrofoam", and it is used because the degradation processes makes the pith looks like a Styrofoam.

CTC13

Productivity: over 100 t/ha.

Precocious variety, with high sucrose content, straight stature and good harvesting. It presents medium fiber content, being recommended for harvesting from the beginning to the middle of the crop, in environments with high to medium production potential. It rarely blossoms and slightly suffers from *isoporização* in the Middle-South conditions. The blossoming is medium in the Northeast conditions. It is resistant to rust, scalding and to mosaic, and it is slightly resistant to yellowing. It presents intermediary reaction to coal and sugarcane borer.

CTC14

Productivity: over 90 t/ha.

It presents high productivity, sucrose and fiber content. It stands out by its erect stature, good harvesting and good drought tolerance. It is recommended to be harvested from the middle to the end of the crop, in environments with medium to high production potential. It rarely blossoms and does not suffer from *isoporização* in the Middle-South conditions. It blossoms a little in the Northeast conditions. It is resistant to rust, scalding, mosaic and to yellowing. It presents intermediary reaction to coal and to the borer. It has a good response to chemical maturers.

CTC15

Productivity: over 80 t/ha.

It stands out by its rather high agricultural productivity and drought tolerance, with excellent ratoon longevity. It presents medium sucrose content and high fiber content. It is recommended for harvesting after the middle of the crop, in environments with low production potential. The blossoming and *isoporização* are medium in the Middle-South conditions, and it present high blossoming in the Northeast conditions. It is resistant to rust, scalding, yellowing and to the borer. It is slightly resistant to coal and mosaic. It has a good response to chemical maturers.

CTC16

Productivity: over 80 t/ha.

It stands out for its high sucrose content, with high productivity and quick closing. The ratoons have excellent sprouting and longevity, including in the mechanized harvesting of raw cane. It presents period of use in the industry long and high fiber content, it is recommended for harvesting in most of the crop season. It can also be cultivated in year-cane system and it is rather responsive, with adaptation to environments with medium to high production potential. It blossoms a little and rarely suffers from *isoporização* in the Middle-South conditions, and it blossoms a lot in the Northeast conditions. It is highly resistant to rust, coal, scalding and yellowing. It presents intermediary reaction to mosaic and to the sugarcane borer. It has a good response to chemical maturers.

CTC17

Productivity: over 75 t/ha.

It stands out by its precocity and high sucrose content, being preferably recommended for harvesting in the beginning of the crop. It presents an excellent performance in sandy soils and in environments with medium to low production potential, being stable in restrictive environments. It presents medium fiber content, rarely blossoms and slightly suffers from *isoporização* in the Middle-South conditions, with medium blossoming in the Northeast conditions. It is highly resistant to mosaic, scalding and to yellowing, and slightly resistant to rust. It presents intermediary reaction to coal and the sugarcane borer. It has a great response to chemical maturers.

CTC18

Productivity: over 90 t/ha.

It stands out by its high productivity in all cuts, including in regions with high water deficit, presenting good drought tolerance. It presents good tillering, it is straight and has great harvesting conditions, with excellent sprouting and ratoon longevity, including in the mechanized harvesting of raw cane. It is responsive, being recommended for harvesting until the middle of the crop. It presents medium sucrose content and high fiber content. It blossoms, presenting medium *isoporização*. It is resistant to rust, scalding, mosaic and yellowing. It presents intermediary reaction to coal and to the sugarcane borer. It has a good response to chemical maturers.

CTC19

Productivity: over 80 t/ha.

It stands out for its high sucrose content, with high agricultural productivity. The ratoons present good sprouting and longevity, including in the mechanized harvesting of raw cane. It present and low fiber content, being recommended for harvesting from the middle to the end of the crop, with very little tendency to culms lodging, and it is adapted to the environments with medium to high production potential. It blossoms a little and rarely suffers from *isoporização* in the Middle-South conditions, and it blossoms a little in the Northeast conditions. It is highly resistant to rust and to yellowing. It presents intermediary reaction to coal, mosaic, scalding and the sugarcane borer.

CTC20

Productivity: over 95 t/ha.

It stands out for its high productivity, high tillering and quick closing. The fiber content is low. It presents high sucrose content and long PUI, being recommended for harvesting during the whole crop. The ratoons present excellent sprouting and longevity, including in the mechanized harvesting of raw cane. It can also be cultivated in the year-cane system and it is highly responsive, i.e., with adaptation to environments with medium to high production potential. It blossoms a little and slightly suffers from *isoporização* in the Middle-South conditions, and it blossoms a lot in the Northeast conditions. It is highly resistant to rust, coal, scalding and yellowing. It presents intermediary reaction to mosaic and the borer.

RIDESA Varieties

RB931003
Productivity: high.
Sucrose content: medium.
Fiber content: medium.
Resistant to: coal, brown rust and scalding.

RB931011
Productivity: medium.
Sucrose content: medium.
Fiber content: medium.
Resistant to: coal, brown rust, scalding and mosaic.

RB951541
Productivity: medium.
Sucrose content: medium.
Fiber content: medium.
Resistant to: coal, brown rust, scalding and mosaic.

RB98710
Productivity: high.
Sucrose content: low.
Fiber content: low.
Resistant to: brown rust and mosaic and it is slightly susceptible to coal and scalding.

RB99395
Productivity: high.
Sucrose content: low.
Fiber content: low.
Resistant to: coal, brown rust and scalding.

RB946903
Productivity: high.
Sucrose content: medium.
Fiber content: medium.
Tolerant to: coal, brown rust, scalding and mosaic.

RB956911
Productivity: high.
Sucrose content: high.
Fiber content: medium.
Tolerant to: coal, scalding and mosaic and it is slightly susceptible to brown rust.

RB966928
Productivity: high.
Sucrose content: high.
Fiber content: medium.
Tolerant to: coal, scalding, mosaic and brown rust.

RB962962
Productivity: high.
Sucrose content: high.
Fiber content: medium.
Slightly susceptible: brown rust.

RB002504
Productivity: high.
Sucrose content: high.
Fiber content: medium.

RB965902
Productivity: high.
Sucrose content: high.
Fiber content: medium.
Resistant to: coal, brown rust, scalding and mosaic.

RB965917
Productivity: very high.
Sucrose content: high.
Fiber content: medium.
Resistant to: coal, brown rust, scalding and mosaic.

RB37570
Productivity: medium.
Sucrose content: high.
Fiber content: medium.
Resistant to: brown rust, tolerant to coal and scalding and slightly susceptible to mosaic.

IAC Varieties

IACSP95-5094 (SP80-3280x?)
Productivity: very high.
Sucrose content: high.
Fiber content: low.
Ratoon sprouting: excellent.
Isoporização: little.
Resistant: coal, rust, scalding.

IACSP96-2042 (SP81-5193 X SP77-5181)
Productivity: very high.
Sucrose content: high.
Fiber content: low.
Ratoon sprouting: good.
Isoporização: little.
Resistant: coal, rust, scalding.

IACSP96-3060 (SP82-6108x?)

Productivity: high.
Sucrose content: very high.
Fiber content: medium.
Ratoon sprouting: medium.
Isoporização: little.
Resistant: coal, rust and scalding.

For many years, genetic improvement programs aimed at selecting varieties that were richer in sucrose, destined to sugar and ethanol production. Currently, all attention is given to the cellulosic ethanol (called 2nd generation ethanol) and to increasing sugarcane biomass for energy creation. Therefore, producing a sugarcane variety with more fiber and less sucrose is a new challenge to be faced.

The analysis of the characteristics of the newest varieties, from the three institutions, and that are starting to be used to replace the existing varieties, shows that all of them have high or very high productivity, over 100 tons/hectare. They have high sucrose content, medium fiber content and great resistance to the main pests and diseases. Figure 6 shows the current technologic stage of sugarcane in Brazil, based on genetic improvement programs and on the cultural practices that are currently being used.

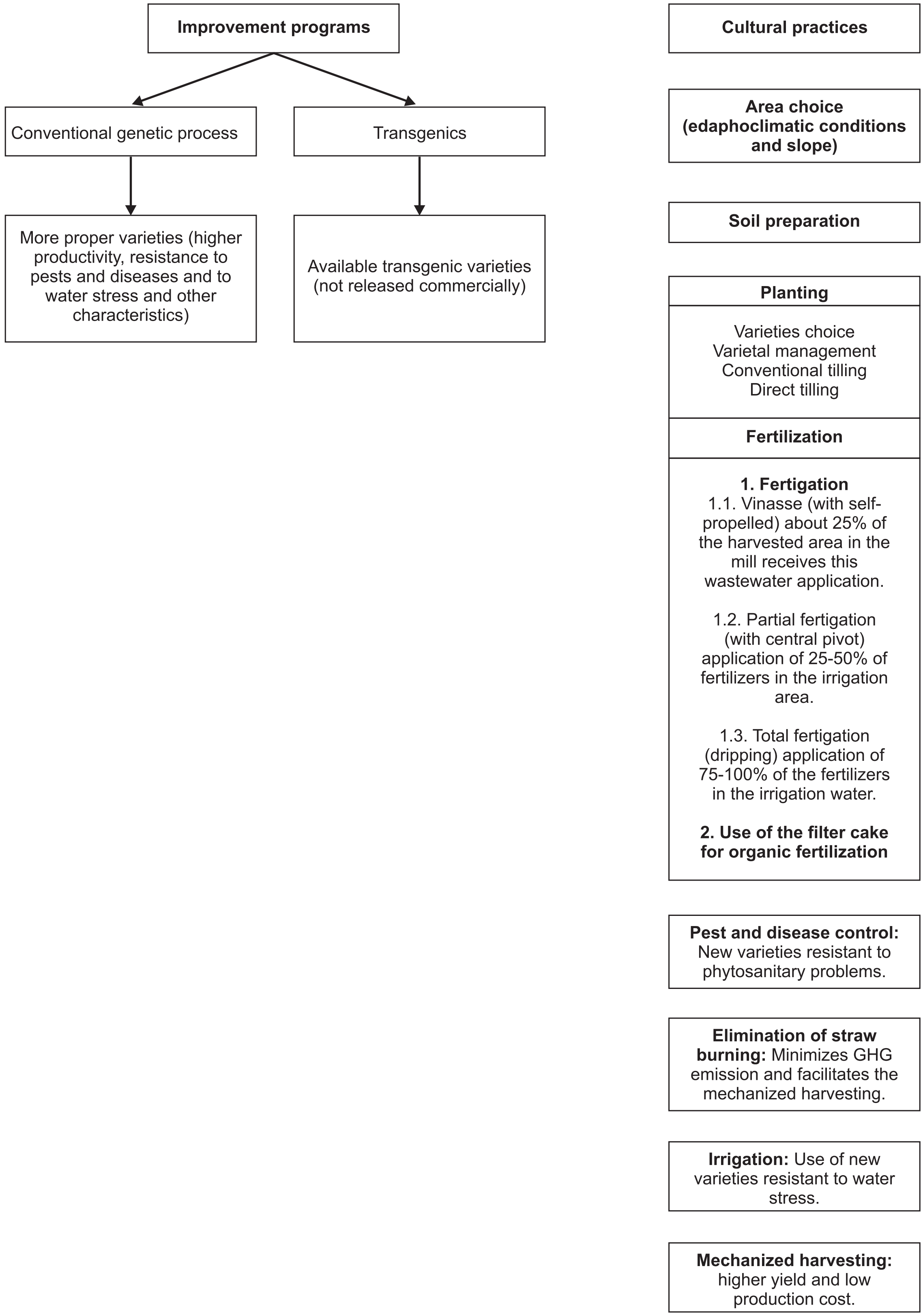

Figure 6. Technologic portfolio of sugarcane in Brazil.

The technologic portfolio in the sector is based on conventional genetic improvement programs or on transgenics, which demand varietal management techniques and cultural practices specialized in all stages of the culture.

New practices such as direct tilling dispense soil disturbance with grids, and producers work with crop rotations, increasing the available organic matter and, consequently, productivity. The sowing is made in the straw from the previous culture, thus avoiding burning the area and releasing carbon oxide. The mechanized harvesting of raw sugarcane, which currently reaches around 70% of the sugarcane produced by mills in the state of São Paulo, eliminates the straw burning stage, reduces labor, minimize greenhouse gases emission (GHG), facilitates the harvest and reduces production costs (NEVES; CONEJERO, 2010).

Sugarcane is a perennial plant in its natural form, but it becomes sub-perennial in extensive cultivation. New planting is usually required between the fifth and seventh harvest. It is necessary because the traffic of machines and vehicles in the crop, which causes soil compaction, directly harms the culture and progressively increases pests and diseases, leading to production decrease in economically unviable levels, thus requiring new plantation. Although the sugarcane productive cycle allows 5 to 7 cuts, the CIB recommends that the replanting should be made after 4 cuts to maintain productivity (CONSELHO DE INFORMAÇÕES SOBRE BIOTECNOLOGIA, 2009).

Even though the mechanization raises some issues such as workforce release, which demands the definition of public policies to absorb this contingent of exceeding workforce in other sectors of the economy, and soil compaction, which can occur with the traffic of machines in the sugarcane plots, bringing some inconvenient to the development of the culture, it provides the following advantages: crop productivity increase, stabilizing the productivity in large numbers and tillage quality improvement by rationalizing the use of herbicides (NEVES; CONEJERO, 2010, p. 30); it also grants economic benefits, since each combine harvester replaces from 80 to 100 cane-cutters, being able to harvest up to 500 tons/day or 6 hectares/day.

Magalhães and Braunbeck (2010), analyzing the harvest process of sugarcane, affirm that even though great efforts to decrease losses and avoid the vegetal and mineral impurities in sugarcane loads delivered in mills have been made, the advances are not significant, and they mention CTC data that indicate that the visible and invisible losses during mechanized harvesting reach 10%, whilst, in other cultures such as soy, these values are around 1%.

Landell et al. (2010) affirm that the average productivity of sugarcane is currently 79 tons/hectare. However, research results indicate that the use of new available varieties related to modern cultural practices may significantly increase these productivity levels. The author bases himself on two scenarios:

Scenario 1 – using more productive varieties with higher sucrose content for sugar and ethanol production.

Scenario 2 – sugarcane varieties which focus in higher fiber content, dissociated from sugar production and directed to biomass production for electricity (cogeneration of energy) and to ethanol cellulosic production. In scenario 1, the sugar content of the current varieties is 15%, and it may reach 16.5% in 2030 to attend the mills that use the conventional sugar and ethanol production system. In scenario 2, which refers to the use and development of varieties destined to biomass production, higher fiber content for electricity and cellulosic ethanol, the estimation is practically to double biomass and fiber production in 20 years, going from the current 79 t/ha and 12% fiber, to 130,4 t/ha and 23%, respectively.

Regarding the cultural practices, the highlight is given to the new fertigation methods, composed of vinasse, which is a residue obtained from the industrial process of ethanol that has high organic matter and potassium content, and that can be used as nutrient supplier and to recover soil fertility. It can be used in three ways: fertigation, partial fertigation and total fertigation. In this same fertilization method, the use of filter cake – a byproduct of the sugarcane industrial process, rich in minerals and organic matter, that deposits in the rotational filters after the extraction of residual sucrose from the dreg – for organic fertilization, is very important. Macedo (2007) affirms that there are expressive research results which prove that high agricultural productivity levels (tons of cane/ha) can be obtained by using these byproducts, besides the reduction of production costs from saving in the purchase of mineral fertilizers.

In the projections made based on the historical data published by IBGE (2003), the planted area and the production present a productivity curve with around 5% growth in the period from 2011 to 2020, Figure 7. However, if the use of new varieties, new cultural practices and the speed in which these varieties are being used are taken into consideration, the productivity with growth curve is much more significant.

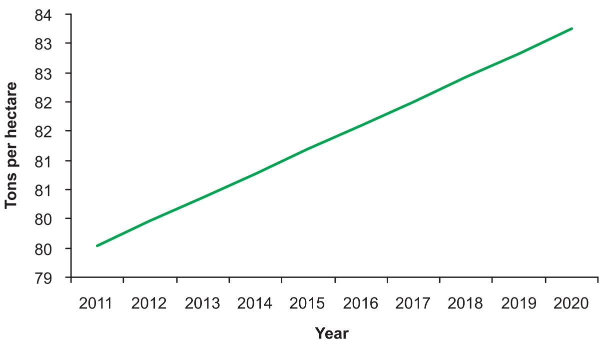

Figure 7. Predicted average sugarcane yield (t/ha).
Source: Primary data from IBGE (1990).

Public policies for environmental control

There are two very important public policies measures: the Agro-ecological Zoning and the Forestry Code Review, which have the regulatory framework necessary to avoid the disordered expansion of sugarcane in Brazil and to guarantee its sustainability.

The last guidelines that promote the consolidation and implementation of public policies that allow the expansion of the sugarcane culture are part of a sustainable social, economic and environmental vision, which make sure that the expansion of the culture in Brazil happens neatly, without harming the existing biomes and avoiding the use of any area destined to food production.

As a matter of fact, there are many myths and true facts regarding this issue. The idea that sugarcane cultivation will increase devastation in the Amazon rainforest, expressed by some countries, is a complete myth. The true facts are: first – the soil and weather conditions do not allow the plantation of sugarcane in the Amazon region; second – a survey carried out by the National Company of Food Supply (Conab) has shown that the cultivated sugarcane area in the states of Amazonas and Pará is 15 thousand hectares, which represents only 0.05% of the total area of both states (CONSELHO DE INFORMAÇÕES SOBRE BIOTECNOLOGIA, 2009); third – the current Brazilian legislation does not allow new cultivations of this culture in these states; fourth – the great sugarcane expansion occurs in the Middle-South region, which is responsible for 80% of the production. In the Northeast region, there very few proper areas available and the concentration and expansion areas of sugarcane are located at 2,500 km from the Amazon region.

The Agro-ecological Zoning (ZAE Cana) was developed by the Brazilian Ministry of Environment (MMA) and the Brazilian Ministry of Agriculture, Livestock and Food Supply (Mapa), based on a thorough study of the climate and soil of the Brazilian regions, considering environmental, economic and social aspects. It was carried out by five research state bodies, amongst which Embrapa, passed to the National Congress as a bill of law, and approved by the Decree 6.961/2009. Its purpose is to guide the sustainable expansion of sugarcane production and the investments in the sugar-alcohol industry, and it is considered an important instrument to lead the expansion of sugarcane production and to avoid damages to food production.

The ZAE Cana prohibits sugarcane cultivation in areas with native vegetation, as well as in the Amazon, Pantanal and Alto Paraguai Basin biomes, and it prioritizes its expansion in underused areas or areas occupied by livestock and degraded pastures, which, according to Mapa, are over 34 million hectares (Zoneamento Agroecológico da Cana-de-açúcar, 2009). This instrument shall be followed according to the specific needs of the states and regions. Neves e Conejero (2010) shows that, in the state of São Paulo, which is responsible for over 60% of all sugarcane produced in Brazil, the restrictions imposed by the agro-ecological zoning are already being implanted. The São Paulo government has been restraining the installation of new mills or the expansion of the existing ones in virtue of the strong sugarcane expansion in the state.

The New Brazilian Forestry Code: the review of the Brazilian Forestry Code is under discussion in the National Congress, in the Special Commission for the Review of the Forestry Code (PL 1876/99). According to the new report of the commission (BRASIL, 2010), the states will have the power to legislate on environmental issues. The punishment on tree felling made under tax incentive will be avoided and the production areas in floodplains and hill tops will be preserved. The Legal Reservation Areas (RL) and the Permanent Preservation Areas (APP) will be kept, but with modified rules, to allow ecological corridors and management demands of riparian, according to the river width. The report will be analyzed and discussed, and will have to undergo the suggested and approved amendments. This is a rather polemic subject; there are controversies between environmentalists, agrarians and political leaderships related to agribusiness. Nevertheless, the subject will have to be approved by the National Congress in the next legislative period which begins in January 2011, and will be as important as the ZAE Cana to guide the expansion process of the sugarcane culture, with environmental sustainability.

Perspectives

Based on the current reality, there are some probable scenarios for the next 20 to 30 years, that is, 2030 to 2040, such as:

- Significant increase in sugarcane productivity, going from the current 79 ton/hectare to around 140 ton/hectare.
- The permission to plant transgenic varieties – that exist since 1990 –, which have a great genetic and productive potential, allowing that the sugarcane culture do not expand into new areas.
- The energy cogeneration process may reach 15,2 GW with the use of over 75% bagasse and 50% straw, providing more energy than the hydroelectric plant of Itaipu (NEVES; CONEJERO, 2010).
- With the technique of 2nd generation ethanol production, which will be available in the next 5 to 10 years, Brazil will have possibilities to increase this fuel production by using the same quantities of agricultural lands currently used. According to Neves e Conejero (2010), in 2005, the production of conventional ethanol in Brazil was 85 liters/ton of sugarcane or 6 thousand liters/hectare. In 2015, the conventional production will be 100 liters/ton of sugarcane and the production through hydrolysis will be 14 liters/ton of sugarcane and 1,100 liters/hectare for 2025. With both processes, it is estimated that it will be possible to obtain 109 liters/ton of sugarcane or 10,400 liters with the conventional process, plus 37 liters per ton of sugarcane or 3,500 liters/hectare with the hydrolysis. The additional production of 2nd generation ethanol alone

will save 3.2 million hectares of land throughout Brazil.

- Bioelectricity, which already make an annual income of 400 million dollars, will have an exponential growth within the next few years.
- The alcohol-chemistry will have a great impulse. Products like the bioplastic, which have already gone into production, will increase in industrial scale in the package market.
- New technologies, such as the diesel derived from sugarcane, the biobutanol and the cellulosic ethanol, will show concrete results in the next few years.
- The new environmental demands, introducing clean development mechanisms – CDM – are promoting investments initiatives in low carbon production, which turns into a great investment opportunity in the production activities in Brazil.

Conclusion

Relevant considerations are to be considered in this section. First, the expansion of sugarcane will happen within the next few years by increasing productivity and by expanding the area. Second, there is no possibility of area expansion in the Northeast region. Researchers at Embrapa have observed in their studies that there has been a decrease of planted areas, therefore, the technological intensification and the use of more productive varieties have been responsible for increasing productivity in the region, and this condition will be sustained in the next few years. Third, the increase of sugarcane productivity in the following years will be very expressive, with chances to go from the current 79 tons/hectare to up to 140 tons per hectare. Fourth, the increase in the productivity levels of sugarcane, even without considering the availability to use degraded pasture areas (with 34 million hectares), which may be used, will make possible to obtain the necessary sugarcane volume in the next years by using the current hectares, being possible to affirm that the Brazilian sugarcane agriculture is going towards efficiency in land use, thus avoiding the depredation of new areas. Fifth, public policies measures, such as the Agro-ecological Zoning of sugarcane for ethanol and sugar production, have excluded, for sugarcane production, areas with slope over 12%, areas with native vegetal covering, the Amazon and Pantanal biomes, environmentally protected areas, Indian lands, forest remnants, the dunes, the mangroves, the scarps, outcrops, reforestation areas, and urban and mining areas. In the states of the Middle-South region (Goiânia, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Paraná and São Paulo), the areas currently cultivated with sugarcane in the crop year 2007/2008 were also excluded. The areas indicated for the expansion by the Agro-ecological Zoning of Sugarcane compose the ones that are currently in intensive agricultural production, semi-intensive agricultural production, special crops (perennial, annual) and pastures. These areas were classified in three potential classes (high, medium and low), discriminated by the predominant current type of use (Ag – Agriculture and livestock, Ac – Agriculture and Ap – Pasture), based on the mapping of the forest remnants in 2002, carried out by Probio-MMA. Therefore, it is expected a production planning that avoids the expansion in areas with native vegetation; sustainable and ecologically clean biofuel production; the cogeneration of electric energy decreasing the dependency of fossil fuels and creating carbon credits; soil and water conservation by conservationist techniques diminishing the erosion of cultivated soils; and the decrease of greenhouse gas emission by progressively replacing burnings with mechanic harvesting (MANZATTO et al., 2009). The review of the Forestry Code has given the Brazilian states the power to define and regulate the obligatory percentage of legal reservation areas in rural properties, which will bring a lot of debate and imprecision as to the use of the current legal reservations. However, regardless of future imprecisions, the common sense, in both the public and private sector, is to maximize the use of current low productivity areas, by improper land use, seeking a higher productive efficiency per hectare for both sugarcane production and food production. This conduct shall create a safe balance for food security, that is, it shall not lead to food scarcity.

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