III

Sustainability of the agricultural production base

The internal sustainability of an agricultural production system requires the ability to respond to pests and plant diseases and to periodical climate changes, among other things. The idea is that these interferences must not harm the production system so seriously as to make it unfeasible.

This sustainability concept is essential to Brazil, which seeks a deeper inclusion in international markets not only in sugar, but also in ethanol. In the case of ethanol, any buyer is concerned about a reliable long term supply.

The problem of periodical climate changes (other than those occurring because of global warming, which are addressed in **Chapter 4**) are usually viewed in Brazil as substantially "under control" in the case of sugar cane because the production areas are very spread, to the point of having different growing periods (as in the Northeast), over a vast territory with remarkable regional differences. As a matter of fact, historical observations of sugar cane production seem to confirm this: only once over the past thirty years was there an important production fall, and even though it took place during a drought year, part of that decrease was intentional (there was an excess of the product on the market, and many mills intentionally reduced the fertilization and cultural treatments, thereby decreasing the sugar cane output).

The ability to respond to diseases and pests is one of the main strengths of Brazil's production. The key of understanding this issue in Brazil assumes that it would be impossible (yet desirable) to maintain a strict, efficient phytosanitary barrier system in a country with such extensive borders as Brazil. The response should consist (in addition to quarantines and barriers) of an efficient disease and pest-resistant variety selection and development system and a proper use of a large number of varieties. This system is shown in **Chapter 10**.

Chapter 10:
Varieties and protection from diseases and pests

Internal sustainability of sugar cane growing in Brazil requires the ability ro respond to pests and diseases and to periodical climate changes. Protection from pests and diseases is considered a strength of Brazil's production: it is based much more on a continued supply of disease and pest-resistant sugar cane varieties than on phytosanitary barriers, allowing growers to operate with a great diversification. Varieties developed in Brazil became commercial in 1980; today nearly 500 varieties are being used.

10.1 Introduction

Brazil's sugar cane genetic improvement programs started providing varieties in the early 1980's. There are four programs today covering the sugar cane growing areas, with an emphasis on the Center-South region. In almost all cases, the search for pest and disease resistance is essential considering how difficult it is to protect the country's territory (and borders) with sanitary barriers.

The expansion areas require some new thinking for the programs with a view to a specific and, in some cases, regional orientation; this is being considered.

In the world context, Brazil has a cutting-edge sugar cane biotechnology, with the development of transgenic varieties. The introduction of such varieties may take place within a few years.

10.2 Standard genetic improvement and availability of varieties

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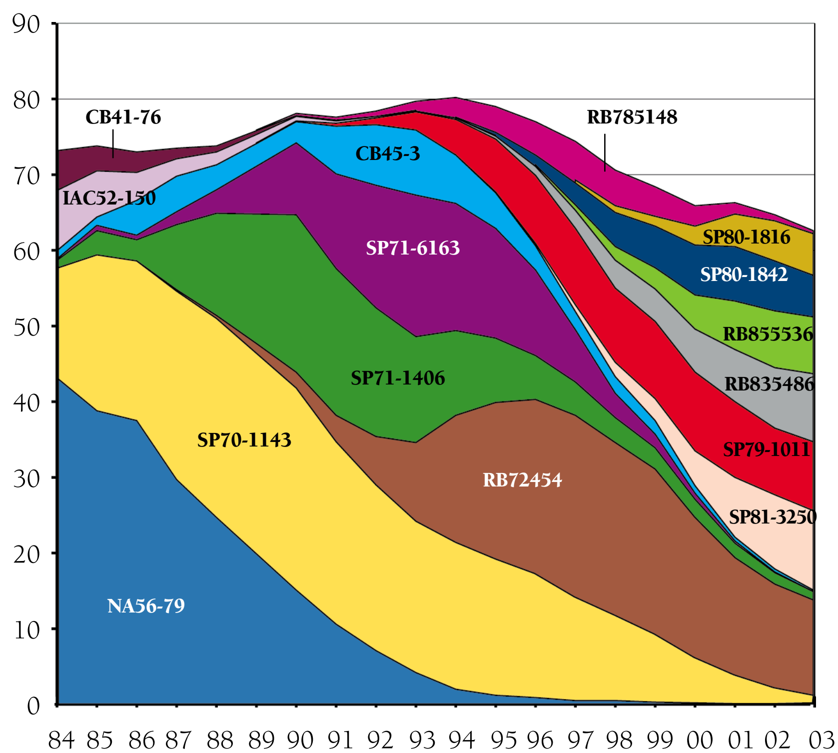
From the production sustainability viewpoint, one of the questions that needs an answer in agriculture is: does the country have an appropriate (sufficient) genetic base for a continued development of new varieties, so as to supply the growing areas with them and be sure that new diseases or pests can be controlled with acceptable losses?

Sugar cane growing in Brazil covers an area of more than 5 Mha in the 27 units of the federation (states). In the period from 1971 to 1997, sugar cane production grew at a mean rate of 5.5 percent per year, while the growing area increased by 3.9 percent per year, and productivity at 1.6 percent per year in a relatively uniform manner. In spite of the expansion to less favorable areas, the productivity increase rates can be attributed, for the most part, to the availability of genetically improved varieties that are adapted for such new conditions. Between 1976 and 1994 (data provided by the PCTS – Sugar Cane Payment System, São Paulo), productivity gains totaled 1.4 kg of sugar per ton of sugar cane each year. Over the past ten years, new varieties have delivered further qualitative advances.

Figure 1: Percentage occupation by the main sugar cane varieties in Brazil from 1984 to 2003



More than 500 varieties of sugar cane are grown in Brazil. Those varieties were produced mainly by two genetic improvement programs: Copersucar's (SP varieties), and the carried out by the Inter-University Sugar Cane and Ethanol Industry Development Network (RIDESA, in Portuguese), formerly Planalsucar (with RB varieties). A third active program, carried out by the Agronomic Institute of Campinas, which has historically been very important to the industry, has been restructured and released some promising varieties. It has recently enhanced its potential, including in biotechnology, and is advancing fast focusing on the Center-South region. Independently, a private company by the name of Canavialis was organized in 2004 to develop sugar cane varieties. That company works in conjunction with Allelyx, which develops transgenic varieties. Therefore, Brazil has two private and two public companies engaged in the genetic improvement of sugar cane varieties.

The two most active improvement programs (SP and RB) were introduced in 1970, when approximately 1.5 million hectares of sugar cane were grown in Brazil. These programs were sufficient to meet the requirements for the major increase in area thereafter. The expansion in the 1970's and 80's took place mostly in regions having less favorable edaphoclimatic conditions, and the development of adapted sugar cane varieties was important for such expansion to succeed. During that period (1970's and 80's), the programs established a broad physical base for conventional genetic improvement. Copersucar's germplasm bank has more than 3,000 genotypes, including a wide collection of "wild" species, such as *Saccharum officinarum* (423 genotypes), *S. spontaneum* (187 genotypes), *S. robustum* (65 genotypes), *S. barberi* (61 genotypes), and *S. sinense* (32 genotypes), which gave rise to modern sugar cane varieties and are sources of the great genetic variability found. It is in the best interests of the various programs for Brazil to have one of the world's sugar cane germplasm collections. A private quarantine facility (approved and inspected by the Ministry of Agriculture) processes 40 new varieties of several of the world's improvement programs every year. The improvement programs have experimental facilities located in the country's main sugar cane growing regions and complement their facility networks with areas provided by producing units.

Brazil has two experimental hybridization facilities where crossings are made: Camamu, in Bahia; and Serra d'Ouro, in Alagoas. The seedlings produced by the Brazilian improvement programs are estimated at 1,420,000 each year.

A census conducted in 260 sugar cane growing units in Brazil in 2003-2004 indicates that 51 out of the 500 sugar cane varieties in use have been released over the past ten years, and the 20 most important of them occupy 80 percent of the crop area, while RB72454, the most widely used, occupies only 12.6 percent. It is gradually noted not only that the permanence "cycles" for the best varieties get shorter and shorter, but also that these varieties coexist in larger number. This great diversification is part of the pest and disease protection strategy. As a matter of fact, the number of varieties in use has been growing faster over the past 20 years, as shown in **Figure 1**. In 1984, if a new disease to which the NA56-79 variety (main variety at that time) was susceptible had been introduced, it would have had the potential for destroying 42 percent of the country's crops. In 2003, if a disease affecting the main variety grown (RB72454) had been introduced, it would have affected only 12 percent of the sugar cane crops.

Compared to those of other important sugar cane research centers around the world (Australia, South Africa, Colombia, and Mauritius), Brazil's genetic improvement programs can be said to be more prolific, and Brazilian growers to be faster in incorporating new sugar cane varieties. Important epidemics were controlled by a fast replacement of varieties. That was the case of the sugar cane smut (1980-1985), the sugar cane rust (1987-1992), and the yellow leaf virus (1994-1997). Today, each of the main varieties occupy a maximum of 10 to 15 percent of the total sugar cane area in each mill. This has been the main defense against external pathogens in Brazilian mills.

The disease and pest-resistant varieties still haven't provided an efficient contribution to minimizing losses caused by some pests, namely, nematoids, spittlebugs, stalk beetles and migdolus.

The genetic improvement programs have also proved efficient in developing varieties adapted for the new management conditions. Recently in São Paulo State, there has been a relative increase in the use of mechanical harvesting of raw sugar cane without trash burning, which provides the crops with much different biological conditions. It hasn't been difficult to select varieties adapted for such new conditions.

Considering the success of sugar cane genetic improvement programs in the past and the wide installed physical base, we believe that the industry will have suitable varieties to safely support the maintenance and future expansion of the crops under any edaphoclimatic conditions in the Brazil. However, some cautions are required. For example, the expansion to areas that have not yet been specifically aimed at by the programs shall require new investments.

The investment in this field of research (conventional breeding) amounts to some R$ 15 million / year in São Paulo, and possibly R$ 20 million / year in Brazil. This corresponds to US$ 1.14 / ha per year; in Australia, the BSES operates with around US$ 12 / ha to create varieties; in Mauritius, US$ 82.2 / ha. Such underinvestment is partly compensated for by the involvement of dozens of companies of the sugar and ethanol industry with the final assessment stages. In the present expansion situation (and relatively new areas), it will be necessary to provide the programs with more funding in order to keep the past development pace, and also to consider the interaction with ongoing transgenic species development programs.

10.3 Transgenic varieties; present situation and prospects

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A significant development of sugar cane biotechnology has been going on in Brazil over the past ten years. The country stands out from other producers, along with Australia and South Africa, for using this modern technology in variety development programs.

In Brazil, the Sugar Cane Technology Center pioneered the creation of transgenic sugar cane varieties in 1997, and has been very active in experimental planting of its findings. CTC had been conducting molecular biology research since 1990 when it headed the conclusion of a cooperation agreement, forming the International Sugar Cane Biotechnology Consortium (ICSB, in Portuguese), an entity with a current membership of 17 institutions and 12 sugar cane producing countries. The Technical Commission on Biosafety (CTNBio) of the Ministry of Science and Technology granted to CTC a biosafety quality certificate in 1997, enabling the growing in a restricted experimental area of varieties featuring resistance to herbicides, pests, diseases and flowering obtained through modern biotechnology techniques. These materials, currently at the experimental stage, are important to the evaluation of benefits and impacts of sugar cane biotechnology.

The development of the Cane Genome project, funded by Copersucar and FAPESP, was extremely relevant. The project was carried out from 2000 until 2003, and mobilized 200 researchers from more than 20 universities and research institutes in Brazil to identify the sugar cane genes. The project described nearly 300,000 sugar cane gene sequences which were grouped into approximately 40,000 genes upon analysis. In this genetic asset of sugar cane, genes were described relating to disease resistance, response to stress, nutrient metabolization, carbohydrate metabolization, transcription factors and flowering process, among other things. Some research groups have already used those genes in genetic improvement programs. The continuity of the Cane Genome project is supported by funds (also by CTC and FAPESP) from the functional genome project initiated in 2004. The preliminary results are promising in the development of varieties which show increased resistance to pests, diseases and some important stresses, such as droughts and cold weather, which could even encourage the expansion of sugar cane crops in regions that are now considered unfit. Another private company (Allelyx) has recently started activities in this field with important resources.

Sugar cane genomics has evolved in Brazil with complementary studies as well, such as the full gene sequencing in 2002 of *Leifsonia xylli*, and important sugar cane pathogen, by a group headed by ESALQ. This will allow a better understanding of the bases on which the pathogenic bacteria and sugar cane interact and the development of mechanisms to put this disease under control. More recently, the gene sequencing was completed of the *Glucanocetobacter diazotrophicus* bacteria associated with sugar cane, which fixes atmospheric nitrogen and could substitute for part of the nitrogenous chemical fertilizers. With the genetic information obtained from the bacteria, the group responsible for this project in Rio de Janeiro expects to increase the efficiency of the microorganism.

Some lack of definition and the complexity of the legislation that governs research and development activities with transgenic organisms in Brazil have been the main barrier to the researchers' activity in this field. Planting experiments with transgenic sugar cane requires the project in question to be approved by agencies related to three ministries, the Ministry of Science and Technology (CTNBio), the Ministry of the Environment (IBAMA), and the Ministry of Agriculture, Livestock and Supply (DDIV). Each of these three agencies has its own particular protocols and requirements, depending on the type of transgenic organism to be tested. The time needed for evaluating the research proposals submitted to each of the ministries has made some projects unfeasible. In addition, there is no clear definition as to the protocol to be followed by the companies who are interested in registering a transgenic product for commercial use.

In terms of technical qualification Brazil is on the cutting-edge of sugar cane biotechnology worldwide, but a major effort should be made on the legislative front so that the country can benefit from this technology over the next 10 years.

10.4 Summary and conclusions

• The internal sustainability of sugar cane growing in Brazil requires the ability to respond to pests and diseases and to periodical climate changes.

• The production conditions in Brazil, with its regional and microclimatic diversity, have been responding appropriately to periodical climate changes.

• *Protection from pests and diseases is considered a strength of Brazil's production: it is based much more on a continued supply of disease and pest-resistant sugar cane varieties than on phytosanitary barriers, allowing growers to operate with a great diversification.*

• There are four operational sugar cane genetic improvement programs in Brazil (the two leading programs are private); they use one quarantine and two hybridization facilities, with germplasm banks. They work with around 1.5 million seedlings per year.

• More than 500 varieties are grown today (51 have been released over the past ten years). The twenty most important varieties occupy 80 percent of the crop area, but the most widely used occupies just 12.6 percent. The substantial rise in diversification over the past twenty years has provided great safety concerning resistance to exogenous diseases and pests.

• Brazil stands out from other producing countries for its sugar cane biotechnology, having had (non-commercial) transgenic varieties since the 1990's. In 2003 the identification of 40,000 sugar cane genes was completed in Brazilian laboratories; there are dozens of groups working on the functional genome, and they are already using the genes in genetic improvement programs (experimental stages). Commercial results may arise over the next five years.

• More funds are recommended in order to properly integrate the germplasm banks for all programs and to support specific developments for each expansion area.

• Efforts on the legislative front should be carried on in order to facilitate the development of biotechnological research in its final stages.