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TECHNICAL PAPER

THE SUCCESS OF THE BRAZILIAN ALCOHOL PROGRAM (PROÁLCOOL) - A DECADE-BY-DECADE BRIEF HISTORY OF ETHANOL IN BRAZIL

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KEYWORDS

strategies, development, agribusiness, world leadership.

ABSTRACT

The National Alcohol Program (Proálcool) was a strategic policy of the Brazilian government to replace petroleum-based fuels with alcohol (ethanol). Based on the review, we can choose the 1960s as a start point for a leap in development. Over the 500 years of sugarcane history in Brazil, the crop enters the second decade of the 21st century with extraordinary strength and prestige, reaching its highest production in history. This made Brazil a leader in sugar and ethanol productions worldwide, with an energy-independent agribusiness. Moreover, effluents and polluting wastes were transformed into high-value inputs (e.g., vinasse, filter cake, and others). Environmentally friendly actions included developing organic cane production technology, ceasing sugarcane field burning, relocating workers from field cutting activities, reducing atmospheric CO_2 emissions. Besides, Brazilian agribusiness has led the search for the "philosopher's stone," that is, transforming pulp or bagasse (polysaccharides) into fermentable sugar for second-generation ethanol production. This paper aimed to present the history and development of the Proálcool Program from decade to decade, as well as showing the actions that led Brazil to assume such significant leadership. This survey highlights the roles of the government, through the Sugar and Alcohol Institute, and of the agronomist Dr Gilberto Miller Azzi, who lent his name to the central building of the Center for Agricultural Sciences - UFSCar's Araras campus.

INTRODUCTION

The history of the Brazilian Alcohol Program (Proálcool) was a saga of outstanding achievements, and it has been told and retold several times by countless authors (Belik, 1985; Rodrigues, 2003; Bertelli et al., 2006; Biodielselbr, 2006, Vieira et al., 2007, Michellon et al., 2008, Gordinho, 2010, Porto, 2010; Figueiredo et al., 2011, Vieira et al., 2011, Pastelli, 2014, Stolf & Oliveira, 2016). All of these narratives are true since the history of the program allows for a many-sided approach, which can not be tied to a single thread in the timeline.

Over time there were a lot of repeated, omitted, and new facts, as well as new characters and interpretations, what has given color, flavor, and substance to record and enrich such a feat of great magnitude. All of these manifestations do indeed form the history of Proálcool and are not just records. After four decades, these records become important to preserve information as a whole.

Based on the above, this paper aims to present, in a timeline, the evolution of the Proálcool program, decade by decade. We decided to start with the decade in which there were facts that led to the establishment of the program. These facts were covered over seven decades (1960 to 2010) to allow association between occurrences over time. Besides that, this paper also focused on:

- Emphasizing that the establishment of Proálcool in 1975 was based on the political and economic international scenario occurring in the end of 1950 decade. The circumstances were strategically used by the Brazilian government through the Sugar and Alcohol Institute (IAA) and the Ministry of Industry and Commerce.

- Highlighting a great effort by public institutions and private sector organizations created afterwards

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(STAB, Copercana, CTC and others) to boost the technological leap over the 15 years preceding the creation of the great project.

CRITICAL REVIEW

1960 - *Decennium mirabilis*

The expression *annus mirabilis*, "miraculous year," has been used as a reference to years of great scientific development. In the past, the year 1666 was referred to as the year of the theory of universal gravitation developed by Isaac Newton. More recently, in 1905, Albert Einstein published four scientific works revolutionizing physics in terms of micro and macrocosms, when the theory of relativity and the photoelectric effect came into existence.

Just as an *annus mirabilis*, we elected the 1960s as a *decennium mirabilis*, since it was the period during which Brazil took the lead in bioenergy.

At the end of the 1950s, Brazil's international sugar quota (550,000 tons) was similar to that of the Dominican Republic and Peru, and 4.3 times smaller than that of Cuba, the world's largest producer at the time (2,414,000 tons) (Ramos, 2007). After commercial embargo imposed by the US against Cuba, a large market was opened for Brazilian sugarcane. The government of Brazil begins to encourage national production and industry modernization. The Brazilian Sugar and Alcohol Institute (IAA) set up an "Exports Division," and started financing new units (distilleries) and field production in new regions of the country. The Brazilian quota only for the North American market reached 360,000 tons in 1963 (Ramos, 2007). The entry into such a preferential market was important because, in addition to higher prices, it brought guarantees and more stability to Brazilian production. On May 19, 1963, Copercana (Sugarcane Growers Cooperative of Western São Paulo State) was founded. Today, it forms the Copercana System, Canaoeste and Sicoob Cocred, which is currently led by Antônio Eduardo Tonielo and Manoel Carlos de Azevedo Ortolan. The system has become the largest global organization linked to suppliers of sugarcane (Copercana, 2016). Months later, on July 16, 1963, another important institution was founded: the Society of Sugar and Alcohol Technicians of Brazil (STAB), formed by a group of 83 technicians from the sector led by Gilberto Miller Azzi, an IAA agronomist, who held the chairmanship of this institution from 1963 to 1966 (STAB, 2010). In this group, there was another young man, an ESALQ Professor, José Paulo Stupiello, a founding partner, secretary-treasurer and president since 1990. He led the STAB to occupy the highest position in the world in number of sugarcane technicians. Since its creation, STAB has led sugarcane science and technology dissemination. In 1966, an agronomic engineering course was created in the Ribeirão Preto region and later incorporated to the State University of São Paulo (UNESP, Jaboticabal campus), supporting the expansion of one of the largest sugarcane-producing regions in Brazil.

Gilberto Miller Azzi advocated a national program for development of new sugarcane varieties. He promoted a successful introduction of the variety Norte Argentina (NA), which has stood out from those in use at the time. This fact has shown Brazil, in practice, the importance of programs for development of new varieties.

In 1966, at the invitation of the IAA, a renowned geneticist, Vicent Mangelsdorf, from the Experimental Station of Cane from Hawaii, was in Brazil on a technical visit. Gilberto Miller Azzi and Carlos Krug, of the IAC (Belik, 1985; Figueiredo et al., 2011), were in charge of following him. After the visit, Mangelsdorf produced a report recommending the creation of a broad agronomic research program in sugarcane to develop new varieties (Mangelsdorf, 1966).

As a result, Gilberto Miller Azzi started then to make the idea public and seek support from the IAA and agribusiness initiatives (Belik, 1985). The first response came from the private sector through Copersucar, which established its technology center (Sugarcane Technology Research Center - CTC) in 1969, and hiring the Hawaiian geneticist himself. This Center had as main goal developing new sugarcane varieties, which were named with the acronym SP. The IAA's strategy was well thought out but had no government input. Such a response, which was already under construction, came soon afterwards at the beginning of the following decade. Finally, Brazilian domination of the world market in the sugarcane sector took place in the 1960s.

1970 - Establishment of the Planalsucar and Proálcool

In 1971, the IAA implemented its strategic plan (Mangelsdorf-Azzi), creating a research department with the main objective of developing a program for obtaining new varieties, the Sugarcane Improvement Program (Planalsucar), which has regional headquarters in Pernambuco, Alagoas, Rio de Janeiro, and São Paulo States.

Gilberto Miller Azzi was given the task of taking over the superintendence of the new institution, remaining until 1976, after succumbing prematurely to disease-related complications. Today, his name remains in a tribute plaque name the central building at Campus of Araras of the Federal University of São Carlos (UFSCar), where the former south-region headquarter of Planalsucar was located.

Seeking to support varietal improvement, the CTC (at the São Paulo state level) and the Planalsucar (at the national level) incorporated to the Program other important areas of study such as agribusiness, sugarcane field management, agricultural mechanization, plant health, pest control, in other words, several other branches of agronomy.

The National Alcohol Program (Proálcool) was established in 1975, during the military government of President Ernesto Geisel. Although the decision to create Proálcool was based on the crisis of high oil prices, the continuous and extraordinary process of technological development (1960-1975) gave the necessary support to this decision.

This program had as goals reducing foreign fuel dependence, saving currency, internalizing development, evolving national technology, providing domestic growth of capital goods, and generating jobs and income (Michellon et al., 2008). Porto (2010) raised a few facts preceding the approval of the program. One refers to a group composed of an agronomist, Roberto Rodrigues, who is from a family of sugarcane producers and Professor at UNESP (Jaboticabal), together with an economist, Victor Argolo, and an industrial director at Usina São Martinho, Agenor Pavan, all developed, in 1973, a project to replace gasoline with sugarcane ethanol, showing

production costs. This project was delivered to president Geisel in November 1974 by Antônio José Rodrigues Filho, the then deputy governor of São Paulo State and president of the Sugar Plantation Cooperative of Guariba. Another fact was the visit of president Geisel to the Aeronautical Technological Center in June 1975, in São José dos Campos, when he assigned Professor Urbano Ernesto Stumpf to test engine adaptation to use of a gasoline-alcohol mixture and to shift them to sole-alcohol-fueled engines. Therefore, in this regard, would have played a decisive role in the resumption of Proálcool in the 2000s, as minister of agriculture.

Many institutions were summoned to act politically and technically in this daring endeavor. The Sugar and Alcohol Institute and its sugarcane breeding program (Planalsucar), which belong to the Ministry of Industry and Commerce, were urged by the government to monitor and act on this evolution. After program implantation, Brazilian ethanol production increased exponentially from 0.6 billion liters in 1975-1976 to 3.4 billion liters in 1979-1980 (Biodieselbr, 2006).

Broadly, one can say that the program was stimulated by the oil crisis in 1973, starting in 1975; then it gained momentum with the 1979 crisis, entering the 1980s in full force.

Shortly after Proálcool implementation, criticism arose naturally due to uncertainties over such an unprecedented idea. Studies proving the feasibility of the program and showing a positive energy balance were brought by Dr José Goldemberg, a physicist, lending credibility thereto. Over these 40 years, Dr Goldemberg collaborated with the subject from the beginning to the present (Goldemberg et al., 2008, Goldemberg et al., 2014), scientifically supporting several publications, debates, symposia, and lectures.

1980 - Boom of the Proálcool

One more achievement, the Union of Bioenergy Producers (UDOP), was founded in 1985 with the leadership of directors from autonomous distilleries in western São Paulo State. Along with these directors, Antônio César Salibe (UFSCar) played a major role in guiding the entity in one of its outstanding aspects. This consisted of training professionals to work in the units, through improving and updating professional courses, held by UDOP Corporate University. Whether in agribusiness or academia, it is rare to find an outstanding technician who has not taught courses at UDOP (UDOP, 2016).

In the 1980s, the Proálcool far exceeded its goal (by 23.3%), producing 12.3 billion liters in the 1986-1987 crop year (Biodielselbr, 2006). But this was a temporary achievement due to fall in oil prices, rise in international market sugar prices, and withdrawal of government financing and subsidies. Such a scenario made people discredit the program, which was aggravated by the supply crisis in 1989 (Michellon et al., 2008).

Despite the crisis, this decade was marked by a pioneering project for organic sugarcane production. With the support of his uncle, Menezes Balbo, Leontino Balbo Jr. approved a project to develop and implement such a system at Usina São Francisco. From 1994 onwards, sugar production system began to be converted into organic. Thus, in anticipation of new prohibitive laws, the Balbo system began to abandon harvesting with burning and use of chemicals, it exempted workers from the manual cutting task and started using organic fertilizers, industrial waste, green manure, and biological pest control, among others. In the meantime, the sugarcane growing area expanded from 7,000 to 14,000 ha. Moreover, the international standard certification for "organic sugar" not only aggregated value but also opened a billionaire market. After its foundation, the export company NATIVA sold the commodity to the largest food companies in the world. Two mainstream international certification companies classified the Usina São Francisco as having the largest continuous area of organic production worldwide (Herzog & Balbo, 2007).

1990 - Decade of darkness and divestment

The 1990s were marked by the end of the Collor de Mello era and by a transitional government between the administration of Itamar Franco and Fernando Henrique Cardoso. During this period, the program continued to decline with market deregulation, product price liberalization, and free competition. This was the time of the scrapping of the ethanol car fleet and the extinction of the Sugar and Alcohol Institute (IAA), which was important for the rise of the Brazilian sugar and alcohol sector, as well as its research department, the Planalsucar. However, a positive aspect stood out at the end of the decade. Businessmen began meeting in an attempt to revitalize the program. Then, they created important entities such as the Association of the Sugar and Alcohol Industries of the State of São Paulo (SUCROÁCOOL), the Society of Sugar and Alcohol Producers of the State of São Paulo (Sopral), Association of Autonomous Distilleries (ADA), and the Association of the Sugar and Alcohol Industry of the State of São Paulo (Sucresp). In addition to these entities, the Sugarcane Industry Union - UNICA (Gordinho, 2010) was also established in 1997.

2000 - Resumption of ethanol: The Second Era of the Proálcool

Added to divestments in the previous decade, the 2000s were marked by the greatest energy crisis in the history of Brazil, at the end of President Fernando Henrique Cardoso's eight years in office, known as “CRISE DO APAGÃO” ("Blackout Crisis"). Brazilian industry expansion was generally abruptly halted. As a result, entrepreneurs would have to invest in diesel generators to continue expansion plans, or else they would have to interrupt projects due to lack of electricity. At that time, the Court of Audit of Brazil had estimated a loss of R$ 45.2 billion in values at the time (Correio Braziliense; "Power outages have cost Brazilians R$ 45.2 billion." July 15, 2009).

It is interesting to discuss versions or set of positive factors that had led to the resumption of a discredited project. Despite everything, the then elected Minister of Agriculture, Roberto Rodrigues, stood firm in defense of Proálcool in an interview with Folha newspaper (Rodrigues, 2003).

Ethanol program resumption has often been wrongly attributed to flex-fuel car development; however, a single technology would never be the main reason thereof. Conversely, several factors had been responsible therefor. Among those, the most relevant was the Roberto Rodrigues’ (the then Minister of Agriculture) convincing

of the then President of the Republic, Luiz Inácio Lula da Silva (January 2003) about how Agroenergy (ethanol, bioelectricity, biorefineries, and biodiesel) could even be new global geopolitics. This is because such type of energy would only be competitive in tropical countries, as it depends on the sun throughout the year. Moreover, these countries were still facing lacks of jobs, income, and wealth, and they could become major producers of such different energy matrix. This would rebalance geopolitics, which was favorable to developed countries. Furthermore, Brazil could be the great global leader of that new geopolitics, which would give emerging countries more inclusive positions on the world stage.

Once convinced of the leading role Brazil could play, Lula embraced agroenergy and traveled the world "selling" this idea. The founder of this thesis and eyewitness of the process was former minister Roberto Rodrigues. Notwithstanding, President Lula has always recognized the minister's contribution to the advent of industry. In short, Rodrigues' proposal was "the icing on the cake" for the government, namely employment and income. According to Vieira et al. (2007), this industrial sector has employed 152 times more people than the oil sector.

2010 – CONCLUSIONS: Sustainability, achievements, and success

In this last decade, we will take stock of the sugarcane sector under the influence of Proálcool, the largest bioenergy program in the world.

Since its creation, the program had been guided more by two of its goals, namely: reducing external dependence on fuel and saving foreign exchange. Thus, it became vulnerable in the 1990s and was almost extinct. But, since 2003, it has been rehabilitated so as to also consider social and political aspects such as employment, income, energy matrix diversification, geopolitical leadership, international prestige, and technology ownership. Therefore, the 21st Century Proálcool no longer depended, within certain limits on oil prices. Thus, it entered the 2010's sustainable, and today, it would be unthinkable to consider its extinction.

Besides stability and sustainability, Proálcool added technology to the farming sector and entered the 2010's with great strength and prestige. In this decade, the highest production of its history was achieved, with a growing trend. Moreover, Brazil became world leader in sugar and ethanol productions, and the largest organic sugar producer worldwide (Herzog & Balbo, 2007). This agribusiness sector became energy independent, promoted electricity cogeneration, and exported surpluses to the national market. Its effluents and polluting residues were transformed into high-value inputs (vinasse, filter cake, and others). Furthermore, environmental actions were taken during this decade such as prohibiting sugarcane field burnings, banning degrading activities (manual cutting at field), producing biofuel in substitution for burning equivalent of gasoline (reducing CO_2 emissions to the atmosphere).

Brazil has become a leader in the search for cellulose–ethanol bioconversion (i.e., bagasse into ethanol). Such technology aims to break polysaccharide (cellulose) chains into fermentable sugar for second-generation etanol production. This had been already studied for years (Stupiello, 1980), but only then it became reality. Currently, sugarcane agribusiness sector has three plants: one on a demonstrative scale (Centro de Tecnologia Canavieira - CTC) and two on a commercial scale (Gr anbio and Raízen). Also in the 2010's, a new concept of energy from sugarcane emerged, wherein bagasse takes center stage. In this context, hybridizations prioritize genes from wild species with a high fiber content, which boosts biomass productivity (Matsuoka et al., 2012 and 2014). If such state-of-the-art proves to be feasible, besides sugary liquid from cane grinding, excess bagasse can be used to produce more electricity, or even second-generation ethanol.

From now on, the sector has started to count on a larger number of national periodicals for sugarcane. All of them are for sugarcane agribusiness, such as: Revista STAB, Canavieiros, AlcoolBRÁS, JornalCana, RPANews, CanaOnline, and CanaMix (a section of the Terra & Cia). These publications cover the entire sector, and some have technical and scientific sections. The first two are ranked in the Qualis/ CAPES system (Brazilian Classification System of Periodicals, supported by the CAPES institution).

Note: The periodical Brasil Açucareiro was the first journal focused on sugarcane agroindustry and edited by an official body, the IAA. It is a historical record that spans from 1934 to the end of 1980. Publication was ceased after the closing of the IAA. It is important for the sugarcane sector to retrieve information and transform into electronic files to be made available in online libraries.

Regarding Brazilian sugarcane breeding in the 1960s and 1970s, the IAA-Planalsucar, under the leadership of Gilberto Miller Azzi, developed and implemented a national program for development of new varieties. After its extinction in 1990, the government stopped investing in research, what was apparently a disaster. Planalsucar's physical assets were transferred to nearby federal universities, which also incorporated the researchers. But, once without government funds, former regional programs of Planalsucar joined private enterprise. Afterwards, an Interuniversity Network for Development of the Sugar and Alcohol Sector - RIDESA was created (Vieira et al., 2011). Given the presence of several universities within the areas of the former coordinating bodies of the Planalsucar, RIDESA has been chaired by deans of these institutions, on a rotating basis. Thus, the breeding program could be continued in 10 universities, namely: UFAL - Federal University of Alagoas, UFG - Federal University of Goiás, UFMT - Federal University of Mato Grosso, UFPI - Federal University of Piauí, UFPR - Federal University of Paraná, UFRPE - Federal Rural University of Pernambuco, UFRRJ - Federal Rural University of Rio de Janeiro, UFS - Federal University of Sergipe, UFSCAR - Federal University of São Carlos, and UFV - Federal University of Viçosa.

As a consequence of the process in which Proalcool was the protagonist, we can list the following:

- RIDESA became the world's largest sugarcane breeding program, developing RB varieties (which stands for *República Brasileira*);

- Sugarcane became the first crop with a genetic breeding program without public investment, as it started to be fully sponsored by private sector, through public-private partnerships;

- In turn, the Sugarcane Technology Center (CTC), created formerly by the private sector, recovered and continued developing new varieties with the acronym SP (São Paulo), always using cutting-edge technologies and starting to act on the world scene;

- Meanwhile, the Agronomic Institute of Campinas (IAC), which had shifted investments to other crops in the 1970s due to CTC and Planalsucar creations, returns to the sector with the Centro Canavieiro, partnering with the private sector as well.

All this raised Brazil to a prominent position in sugarcane research and, as rarely happens, receiving private sector investments.

This fantastic story shows the participation of three government ministers who were Proálcool defenders, namely: Shigeaki Ueki (Mines and Energy), Roberto Rodrigues (Agriculture), and José Goldemberg (Education). Two of them are scientists and academics: Roberto Rodrigues, Professor and Honorary Doctor at UNESP; and José Goldemberg, former Rector of USP and renowned physicist specialized in energy resources, and with an outstanding performance in defense of bioenergy in Brazil.

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