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INTRODUCTION

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The perspective of a significant increase on ethanol demand as a renewable biofuel energy source requires, without doubt, an increment of the raw material production in quality and quantity in a sustainable way. To supply this demand, specialists have foreseeing the need for expansion of the cultivated area of sugarcane from the current 7.3 million hectares in 2008/09, to 14 million hectares in 2030. This expansion will require major changes in the whole productive system. Therefore agricultural production technology for sugarcane should be improved with focus not only on productivity, but mainly in the reduction of environmental impacts.

Considering the current bottlenecks of the agricultural production and the goals to be reached, along 2007 and 2008 several workshops[1] were held to discuss with the technical and scientific community the expectations in terms of R&D&I to build a new model of sugarcane production from the agricultural point of view. This new model is presented and discussed in this part of the book.

The section begins with the discussion presented by Souza and Van Sluys on the challenges of the genome-base technology and biotechnology of the sugarcane. The authors point out that one of the challenges is to achieve new productive varieties adapted to the several existent environments in Brazil. The genetic improvement is limited by biological barriers that can be overcome with the transgenic techniques, or strategies of vegetable improvement. This could enlarge the potential of the already existent cultivars as well as the development of new cultivars by "marker-assisted breeding". The chapter presents, in clear manner, which are the actions that are being taken in this field of science, the groups that are involved and what is necessary to guarantee top quality research in sugarcane biotechnology and to qualify geneticists in Brazil.

In the third chapter, Gazaffi *et al*. what has been accomplished in terms of genetic-improvement and the progresses obtained in the genetic mapping of sugarcane. The authors describe how improvement occurs, its stages, the material selection, evaluation and experiments. They explain what the genetic mapping is and the strategies that have been used to construct the sugarcane genetic maps. The importance of the molecular markers and the existent limitations in the case of the sugarcane are discussed and the benefits of its use in the genetic improvement appeared. The mapping of QTL's (quantitative trait loci) that has been used to name the chromosomes areas that contain genes (or locus) that control the polygenic characters, and the results obtained for sugarcane are also presented.

In this new model an important and interesting approach is presented by Leal in the Chapter 16 of the Part 4 regarding a new cane known as "energy cane" replacing partially the current sugarcane. This transformation is associated to the fact that the electric power generated from sugarcane will

[1] These workshops were part of the project "Guidelines for public politics for sugarcane industry in the state of São Paulo" financed by FAPESP.

have a more important role in the Brazilian energy mix. For that is necessary to alter the system now employed for the raw material remuneration at the mill where today only the sucrose content is evaluated. In the "energy cane" the straw (tops and leaves), that today in many places is no longer burned as form of facilitating harvesting and currently mostly wasted will be used economically in the boilers for electric power generation. The content of fiber present in the stalk should also be valued, not only for a more efficient bagasse burning, but for production of ethanol by hydrolysis. In this way it should also be considered by our geneticists how to obtain varieties that produce larger amount of biomass per hectare per year.

Another important approach discussed here is the photosynthesis potential that can be extract from sugarcane. As the objective is to obtain the total use of the sugarcane where the whole biomass is useful to the industry, the challenge is how to maximize the transformation of solar energy in to recoverable energy. This is one of the great challenges that our researchers will have to face in the coming years, because although sugarcane is one of the most efficient photosynthesizers in the plant kingdom, (it is a C-4 plant, able to convert up to 2 percent of incident solar energy into biomass), the photosynthesis process in sugarcane is not yet totally dominated.

This discussion is completed with the following chapter by Buckeridge *et al*., on the routes for the production of cellulosic ethanol in Brazil. Besides the current route, the authors discuss the generation from the acid hydrolysis of the bagasse, second generation; of the cellular wall using microorganisms enzymes, third generation; and the fourth generation that would comprehend an integration of all the generations, but with a new raw material (sugarcane varieties) modified genetically and capable to accomplish modifications in the cellular wall that would turn into a more efficient the process of the third generation. The chapter presents the potential and the barriers that exist in each one of these routes, and discusses the necessary progresses in the field of research to achieve a production of renewable energy in a clean and efficient way.

Changing the approach from Chapter 8 on begins a discussion from the agricultural point of view. Rossetto *et al*. discuss how sugarcane production has been exploring the soil, this limited resource. Which are the actions that were accomplished along these years to minimize the action that degrade and pollute the soil and which are the research needs to reach sustainability. The authors show how the cultivation of sugarcane for many years is affecting the chemical, physics and morphologic properties of the soil. They also approach the problem of the erosion, and the technological progresses that appeared as a consequence of the crop system without burning, and how it was possible to reduce the loss of soil from 100 t/ha^{-1}, or more in some cases, to less than 7 t/ha^{-1}. The conservation tillage methods such as no-tillage and minimum cultivation are among the new technologies that are being implemented for sugarcane cultivation. With this technology, as example of what happened in cereals, it is possible to reduce soil compaction, to obtain increments of the organic matter and in soil fertility, larger productivity and longevity of the ratoon.

However, as point out by the authors, this practice is not yet totally viable for sugarcane as a consequence of the intensive traffic of vehicles during whole process of crop production, where the soil in about 60% of its extension is crossed by heavy machines. The solution of this problem requires to break paradigms and the development of specific technology for sugarcane e.g. as is the case of the Bioethanol Science and Technology Laboratory (CTBE). This proposal schematized illustrated in Figure 1 consists of using a wide frame equipment (Structure of Controlled Traffic – ETC) specially designed to execute all operations involved from the planting to the harvesting of the sugarcane, with a minimum contact between tires and plants. This is possible because the wheels of the equipment run along permanent tracks (spaced 12 m from each other), which are previously defined and georreferenced. This reduces the traffic of agricultural implements in the sugarcane fields to less than 10% of the planted area. Such conditions will enable gains in productivity and increase the longevity of the ratoon, thanks to the improvement

FIGURE 1 Controlled Traffic Structure (ETC) proposed by Bioethanol Science and Technology Laboratory – CTBE – as part of the Low Impact Mechanization (MBI) project for sugarcane production.

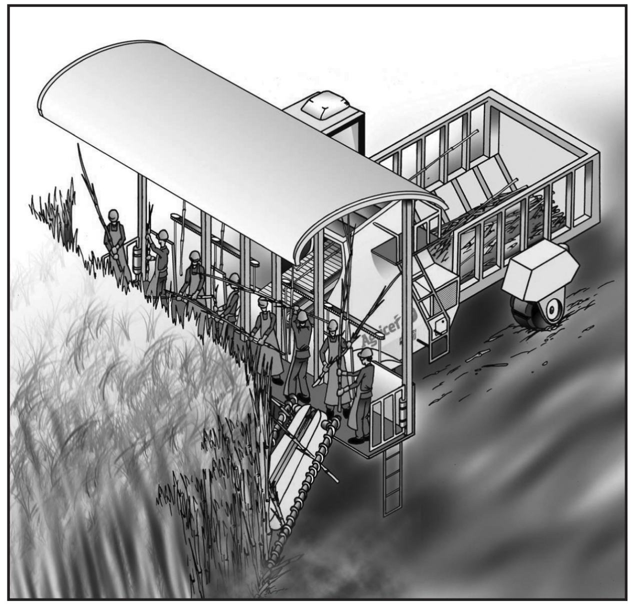
of the physical structure and of the biochemical properties of the soil. Reduction of losses of nutrient and of soil water will also occur through the use of this system. The mechanization of low impact (MBI) involves changes in the two main pieces of the current sugarcane mechanization: the agricultural tractor and the sugarcane harvester.

If the maintenance of the trash (composed by green and dry leaves and top of sugarcane) in the field brings evident benefits to the production of the sugarcane, as mentioned by several authors presented by Rossetto *et al.*, it has also some drawbacks, as delay ratooning causing a reduction in cane yield when temperatures are low and the increase incidence of pests' population that shelter and multiply under the trash mulch affecting the quality of the raw material. This theme is discussed in Chapter 11 where Parra *et al.* describe the main pests and diseases that commit the production of sugarcane and how the incidence of these can be affected by changing cultivation methods. The principal objective of the chapter is to show the perspectives using biological control and what should be accomplished, in research terms, so that the measures control alternatives contribute to maintainable production of the sugarcane.

Cantarella and Rossetto, in Chapter 9, present the solicitations of the plant in terms of nutritious. Sugarcane as a tall semi-perennial grass of the genus *Saccharum* (family Poaceae) has a great demand of minerals nutrients that constitute from 3 to 5% of the whole dray material produced and removed from the field. In that way it is necessary to replace, through organic/chemical fertilizer, these nutrients. The authors affirm that there is a vast accumulated experience in fertilizing and nutrition of the sugarcane for soil conditions in Brazil, the result of studies accomplished by several research centers, and discus the needs of the plant and the methods recommended for soil fertilizing. However, the fertilizing technology is not yet totally solved, and gaps exist in this context that needs to be study so that ethanol can be obtained in a sustainable way. The authors also look at some items, among them the problem of the handling in long period Nitrogen fertilizer in green sugarcane.

The vinasse, a by-product of the ethanol distilleries, that was a huge problem for the sector some years ago, today due to its chemical constitution, is used through fertirrigation as a source of nutrients for the soil. The composition of the vinasse is very variable as function of several factors, with chemical elements that were absorbed by the sugarcane, coming from the soil, such as potassium, sulfur, phosphorus, nitrogen, calcium, magnesium, besides the micronutrients, whose concentration varies from field to field. In spite of this, vinasse use can cause negative impacts to the environment and its application should under clear criteria. Several questions of how to treat this residue especially with a perspective of tripling sugarcane production in a near feature become a critical issue. Alternatives for vinasse use should be found, as concentration, biodigestion, incineration or proteins production. This is the theme of the Chapter 10 produced by Mutton *et al.*

Braunbeck and Magalhães present a technological evaluation of the mechanization of the sugarcane. They discuss here that the development of the mechanization of the sugarcane followed the existent model for cereals production, in spite of the crops present very different characteristics. These agricultural machines and available equipments were adapted for sugarcane cultivation and harvesting, generating difficulties to the sector. The authors show the existent antagonisms in the current model and they defend the hypothesis that it is necessary, from the economical and environmental point of view, to develop specific mechanization solutions for the sugarcane, focus in the reduction of the field traffic. The development of this technology will bring benefits to the sustainability of the sugarcane plantation activity promoting the reduction on investment and increment in the productivity. In this chapter again the problem of the protection of the soil and of the use of the trash is approached, emphasizing the need of maintaining a fraction of the trash over the soil and the benefits that this practice brings to the environment. The authors defend the adoption of the no-till cultivation method for sugarcane, but point out that to introduce this innovations it is necessary to make investments in research and necessary development to eliminate, or to draw round, the associated obstacles related to the those changes.



Source: AGRICEF-FEAGRI/UNICAMP.

FIGURE 2 Green sugarcane harvest aid.

In Chapter 13 Magalhães and Braunbeck synthesize what was discussed in the workshop of sugarcane crop and straw harvesting for the ethanol production. There are many difficulties for harvesting green sugarcane (without burning) in current model which requests high investments, presents low field efficiency, high consumption of fuel, degrades the soil, and eliminates the small and medium producers. The lack of available technology to pick up the straw, which represents a third of the sugarcane crop energy and remains on the soil to waste is also discussed. The author present some alternatives that can be explored and the investment need in R&D in this area is pointed out. One alternative for reducing the impact caused by the necessary and inevitable mechanization of the sector is the employment of harvest aid equipments for sugarcane, as shown in the Figure 2. This equipment, capable of harvesting several row simultaneously, depends on two pickers for each row to remove the stalk, cut by the machine and conducted to the platform in front of him. The pickers have to direct the sugarcane stalk to the mechanism for de-trashing before it is send to a storage wagon attached to the device. Design concept maximized the pickers' time spent locating and cutting sugarcane stalk and removing the leaves. In medium to high yields, the picker productivity can be increased by 40 to 60% over conventional manual harvesting, guaranteeing in this way the rural employment and mainly the quality of life of these pickers. Due to designed balance in the device dimensions which guarantees low center of gravity, this equipment should work in areas with slope of up to 40% that, together with its low acquisition cost and maintenance, should assist the needs of most of the sugarcane small/medium growers that otherwise would be forced to abandon the activity. The author mentions yet other emerging technologies that need investments to become economically viable and contribute to the sustainability of the system, such as the use of the precision agriculture (PA) and automation of the field systems.

This subject is approached again in greater detail by Ynamassu and Martin-Neto in the Chapter 14. In sugarcane, the progresses in the use of precision agriculture technologies are still modest, in spite of the technological advantage in ethanol production. These are probably due to the difficulty in obtaining tools and support that aid in the measurement of the crop space variability. In this context the role of the automation according to the authors, has been the replacement of labor in the search for the increase of efficiency and competitiveness. The adoption of the PA introduces changes not only in the form of administration of the property, but it also demands transformations in the market of machines and equipments, because the adoption of electronic equipments for monitoring and control will demand standardization of communication protocols as fundamental aspect to enlarge the versatility in the use of the equipments of different manufactures. The authors outline the research opportunities in the instrumentation area and automation for handling of the trash, monitoring of the soil and of the dynamics and reactivity of the organic matter.

With authority, the subject of the logistics of the sugarcane agricultural sector is discussed by Braunbeck and Albrecht Neto in Chapter 15. The logistics of the transport involves variables of the agricultural and industrial areas of the company, besides those specifically inherent to the transport; therefore a good logistic administration allows reducing the production costs significantly. The authors divide the chapter in three items, first the cut logistics, loading and transport of the sugarcane. Nowadays these items have been the subject of several studies comprising a series of technologies which include optimization of the employed materials in the production of trucks to the use of the information technology and precision agriculture. Secondly, they approach the problem of the trash, today left in the field, but that soon should be used to generate energy and it will require new logistics, depending on the technology that will be used in trash recovery. On the third part, the authors discuss the problem of logistics of distribution of residues from the agro industry such as vinasse, filter cake and ashes that are associated to transport operations with varied importance depending of the amount produced.

Arraes *et al*. synthesize the result of the workshop of Administration accomplished in the Center of Technology for Sugarcane CTC in Piracicaba in Chapter 16. The authors show how the progresses of the information technology have been aiding in the agricultural administration, demanding changes in the culture and in organizational practice. As the adoption of the of processes administration models, integrating the core functions of the enterprise: the industrial production, the human resources, the finances and the relationships with suppliers and customers – ERP´s (Enterprise Resource Planning), made possible to obtain and processing the information allowing to enlarge the temporary frequency and the number of variables to consider in the decision support system. The adoption of precision agriculture is a direct reflex of the administration technologies. In their final considerations, the authors suggest some alternatives that could promote the technological progress in the administration of the sugarcane sector.

In the last chapter of this section of the book, Leal *et al*. present the potential of using other crops as a source for ethanol production. Although more than 90% of the current world ethanol production is made from corn and sugarcane, a growing interest exists for other renewable sources. In this chapter, the authors consider two groups, one already consolidated by crops with technology for agricultural production well developed, and another composed by species that showed high biological potential of production on an experimental level, but lack the technology for appropriate agricultural production to the Brazilian conditions.