A Standard Analysis of Genetically Modified Crops

Mrs. Sagrika Goswami, Dr Jitendra Singh
SOA, Sanskriti University, Mathura, Uttar Pradesh, India
Email id-sagrikag.somc@sanskriti.edu.in

ABSTRACT: Global sugar cane interest has grown substantially in recent years as a result of its economic effect on the generation of renewable energy. Sugarcane breeding and improved agricultural techniques in the last 30 years have led to a massive rise in the output of sugar cane. Further improvements in sugarcane production are anticipated in the near future as a consequence of the application of biotechnology instruments. Genetically modified (GM) sugar cane, which includes genes to enhance biotic and abiotic stress tolerance, may play a significant role in accomplishing this objective. In order to get GM sugar cane to the market, however, a regulatory procedure must be followed that assesses the environmental and health effects of this crop. The procedure of regulatory examination is typically done by comparing the biology and composition of the GM cultivar with a non-GM equivalent. It is intended to educate regulatory bodies in decision-making about the commercial release of GM sugarcane cultivars on GM sugar cane biology, genetic engineering, breeding, agronomic management, processing, products and byproducts, and current technology for the development of GM sugar cane.

KEYWORDS: breeding, Cultivars, Gene, Genetically Modified, Sugarcane.

1. INTRODUCTION

Sugarcane has seen a considerable rise in economic interest in recent years, owing to an increase in global demand for environmentally friendly energy generation methods. Due to Brazil's success in sugarcane ethanol production, a consolidated global supply is now being established to satisfy the need for ethanol additions of about 10% to gasoline across the globe, which is now being considered. It is predicted that the Brazilian sugarcane output will need to increase in the next decade in order to achieve this objective. Increasing sugarcane production has a negative effect on the environment, and biotechnology advancements may be able to mitigate this impact in the future by creating solutions that produce more sugarcane while using less fertilizer and water[1].

One of the most important of these options will be genetically modified sugarcane, which will provide farmers with more productive and resistant kinds. Field experiments using genetically modified sugarcane in Brazil have already been authorized by the National Biosafety Technical Commission (CTNBio). These trials will include characteristics such as enhanced yield, drought tolerance, insect resistance, and herbicide tolerance, among other things. It is anticipated that the massive research and development activities being carried out by the government and private institutions would culminate in the commercial release of genetically modified sugarcane in Brazil in the medium future, assuming everything goes as planned[2].

This study was created to serve as a source of baseline information on conventional sugarcane in order to aid in the decision-making process about the potential commercial release of genetically modified sugarcane cultivars in the near future. There are several aspects of sugarcane's biology that will be discussed in this section: its origins, the agronomic behaviour and growth habit of sugarcane, the botanical aspects of sugarcane's reproductive biology, the potential for lateral gene transfer by pollen, the model of seed dispersion used by sugarcane, and the allergenicity of sugarcane products. Aspects of this review that are relevant to sugarcane consumption and byproducts produced by the sugarcane agribusiness are also discussed[3].

1.1 Importance in Terms of the Economy:

Since the beginning of the 16th century, the sugarcane crop has played an important role in the development of the Brazilian economy. The first sugarcane plants were transported to Brazil from Madeira Island and planted in 1515; the first sugar factory was built in 1532. The sugarcane industry has a long history. As of 2009/2010, Brazil is the world's biggest producer of sugarcane, with about 7.5 million acres under cultivation and a total production of roughly 612 million tonnes throughout the crop season. Approximately half of the sugarcane was used to make sugar, with the other half being used to make ethanol, which produced 25 billion litres in total. Apart from sugarcane for human consumption, Brazil also produces animal feed, cachaça (sugarcane alcohol), and sugarcane syrup, among other things[4].

Brazil's sugar and ethanol exports produced about US$ 9.9 billion in income in 2009, placing sugar-cane as the country's third most valuable export after oil and natural gas. Due to a combination of extremely favorable factors, the Brazilian sugar-ethanol agribusiness is currently experiencing an exciting period, including prospects for growth in both internal and external markets, a long-term trend of rising international oil prices, possession of the world's lowest ethanol production costs, expansion of the flex fuel fleet, and a widespread concern for environmentally friendly ethanol production. Because of these circumstances, the Brazilian fuel ethanol programme and the country's ability to meet a substantial portion of the world's need for renewable fuel have received widespread international attention. In turn, sugarcane output has increased significantly in recent years as a consequence of these developments. 2007 saw a 12 percent increase in planted area over the previous year, and it is projected to continue growing at this rate for the next few decades[5].

1.2 Potential of Lateral Gene Transfer:

Commercial sugarcane production is carried out entirely with the use of vegetative propagated material derived from commercial hybrid varieties. Sugarcane pollen is transported by the wind under perfect blooming circumstances, with no involvement from animal or insect vectors. As a result of the limited vitality of sugarcane pollen, natural hybridization can only occur within a short distance of the pollen-supplying plant. As a result, minimal seed set is anticipated since pollen loses its viability very quickly.

Although natural hybridization between species of the genus Saccharum and other closely related species has been proposed to occur in the wild, no evidence of wild hybridization with contemporary sugarcane cultivars has been found. Each of the species that comprise the "Saccharum Complex" has a distinct degree of sexual compatibility with S. mutans. S. officinarum and S. officinarum Under artificially regulated crossings, spontaneum may occur. Cross-pollination between sugarcane species and the Erianthus sect. Under the influence of breeders, the occurrence of Ripidium and Miscanthus species is more likely than the occurrence of Narenga and Sclero-stachya species.

Natural circumstances, on the other hand, result in considerably lower levels of genetic transmission between commercial hybrids and these original species, if any are present. There are no members of the "Saccharum Complex" species that are endemic to Brazil, which is a crucial point to remember. Furthermore, there is no information available on the biology of wild Brazilian Saccharum species such as S. edulis. S. villosum et al. S. asperum is a kind of asperum. S. angustifolius and S. angustifolius baldwinii, nor on the potential of gene flow happening between them and commercial sugarcane hybrids, are now under investigation.

Although the Saccharum species responsible for the development of commercial sugarcane varieties (S. officinarum and S. spontaneum, with minor contributions from S. robustum, S. barberi, and S. sinense) are not native to Brazil, the species that gave birth to commercial sugarcane types are. These species are exclusively found in Brazil's germplasm collections, which are utilised in the country's sugarcane breeding efforts. They have the ability to bloom synchronously and effectively hybridise with contemporary cultivars when grown in a breeding facility setting. However, under natural Brazilian climatic circumstances, it is unlikely that lateral gene transfer would occur between contemporary sugarcane hybrids and those species[6].

1.3 Sugarcane Cultivation for Commercial Purposes:

The first stage in creating a commercial sugar-cane field is the production of vegetative planting material from the chosen commercial variety in nurseries under hygienic circumstances that have been authorized by the local government. Because it is common practice to use thermotherapy (hot water treatment to control systemic bacterial infections such as ratoon stunting disease) or meristem culture (which is free of bacteria and viruses) to ensure disease-free starting material, it is common to treat the stalks to be used as planting material before planting, or to use a combination of these methods to ensure disease-free starting material. The following are the three kinds of nurseries, which vary mainly in size and number of generations away from the time of the first asepsis:

1. Basic Nursery, also known as Pre-Primary Nursery, is made up of buds from the previously stated treated stalks or meristem propagated plants. Pre-Primary Nursery is made up of buds from the previously mentioned treated stalks.

2. The Primary Nursery is descended from the Basic Nursery, although it is about 10 times bigger than its parent nursery. The Basic Nursery's first ratoon is sometimes referred to as the Primary Nursery since it contains the youngest children.
3. The Secondary Nursery is a branch of the Primary Nursery and is 10–15 times bigger than the preceding nursery in terms of space. Secondary Nurseries may be found in the second ratoon of the Basic Nursery and the first ratoon of the Primary Nursery, among other places.

Commercial plantations are often developed using time-tested traditional techniques that have been proved over time. Plowing is done to a depth of 30 cm, and the furrows are cut to a depth of 25–30 cm. Rows are placed at intervals ranging from 0.8 to 1.5 m apart, and each hectare is planted with 8–12 tonnes of planting material, depending on the variety. To ensure that the buds from the top portion of the stalk germinate better than those from the base, stalks are placed in pairs with the base of one stalk paired against the upper part of the other, i.e., two stalks laid in opposite orientations.

After the stalks have been evenly dispersed across the furrow, they are sectioned into 2 to 3-node seed pieces in order to disrupt the apical dominance that occurs in the unbroken stalk throughout the growing season. Pesticides are sprayed over the cuttings in the furrows in soils that have been identified as being infected with insect pests or nematodes. The last stage in the planting process is to cover the cuttings in the furrows with 10–15 cm of soil, which is the final step in the planting procedure[7].

In Brazil, irrigation is usually not required in commercial sugarcane fields, which contributes to the country's cheap production costs. Because the sugarcane business is expanding into marginal production regions, which are mainly drier areas with little rainfall, drought tolerance is becoming a more essential characteristic for sugarcane types, according to current thinking. Weed management is the most essential agronomic activity after the crop starts to develop. Weed control is also the most time-consuming. As soon as an optimum plant stand has been formed, the primary focus should be on implementing measures that ensure excellent crop growth in order to achieve good maturity, i.e. sugar accumulation, in the shortest amount of time. Proper harvesting and milling procedures ensure that harvesting and milling processes are optimized, and that the total economic return is maximized. This goal is accomplished by mills growing a variety of cultivars with varying soil nutrient requirements, maturation rates, and disease resistance that are all dependable[8].

Sugarcane harvesting in Brazil is either semi-automated or fully mechanized, depending on the region. Cane is harvested manually in the first instance, but it is mechanically put onto trucks in the second. The cane is harvested by machines, which then load it straight onto trucks in the first case and the second case. Although the completely automated harvest method has the benefit of not needing a previous burning phase, it cannot be implemented everywhere since existing harvesting equipment are unable to work in places where the slope exceeds 15–17%.

1.4 The Sugarcane Crop Cycle in The Commercial Sector:

In commercial fields, sugarcane is a semi perennial crop that grows from year to year. When cultivated under the rainfed conditions of Brazil, it requires replanting roughly every three to six harvests. Planting is needed owing to decreasing yields caused by crop and soil damage caused by high traffic of equipment and trucks over the stumps during harvesting, which has resulted in crop and soil damage. In addition, there may be a gradual buildup of infections in the sugarcane crop over time, with certain diseases reducing stand population and others impairing plant development. Because most commercial cultivars have been chosen to produce well only during the first three to four culture cycles, it is possible that a genetic component is contributing to the decrease in production. Ultimately, this results in a reduction in annual production that may reach economically unsustainable levels, necessitating replanting of the area[9].

The production of sugarcane is divided into two main cycles. The plant-cane cycle begins with the sowing of the seeds and concludes with the first harvest. The ratoon cycle, also known as the ratoon-cane cycle, begins after the harvest of the plant cane and continues with consecutive ratoon crops until the land is renewed. The whole cycle of a sugarcane field lasts four or five seasons, after which the crop is harvested and replanted in the same location. Following the harvest, ploughing the crop under and harrowing the soil is done, which is frequently preceded by the use of a systemic herbicide to ensure complete eradication of the crop after it has become economically untenable[10].

2. DISCUSSION

In the field of polymeric materials, biopolymers are polymeric-based materials that may be structurally divided into three categories: polysaccharides, polyesters, and polyamides. The most fundamental raw resource for manufacturing is a renewable carbon source. Biopolymers such as polylactate (PLA), polyhydroxyalkanoate (PHA), starch polymers (PA), and xanthane are among the most widely used (Xan). Scientists have discovered that, of all the raw materials available for biopolymer synthesis, sugarcane has one of the finest characteristics as a carbon source, outperforming all others. Sugarcane has a distinct competitive advantage over other carbon sources due to the high concentration of lignocellulosic fiber in bagasse, which may be utilized to produce the energy required for biopolymer synthesis.

The sugarcane genome is one of the most complicated of all the crops that have been grown. This intricacy has hampered our understanding of sugarcane genetics, as well as our capacity to enhance the crop via the use of biotechnology techniques in the last several decades. In situ hybridization studies on sugarcane genome organization were carried out in the late 1990s and helped to elucidate how the genome is structured. An extensive body of research has documented a portion of the species' complexity and firmly confirmed the species' ploidy level, while also demonstrating the presence of two different genomic organization patterns in contemporary variations.

Sugarcane's genome was sequenced using an artificial chromosome library with over 100,000 clones, which allowed researchers to begin physical mapping of its chromosomes and comparisons with other grasses while still in the early phases of their research. Meanwhile, EST (expressed sequence tags) sequencing studies were initiated by many research organizations in South Africa, Australia, and Brazil during the same time. Until recently, the Brazilian sequencing effort SUCEST (Sugarcane EST Sequencing Initiative) was the project with the greatest contribution of sugarcane EST sequences, having sequenced 238,000 ESTs from 26 distinct cDNA libraries.

Methods for genetically modifying sugarcane were first described more than three decades ago. Electroporation and polyethylene glycol treatment were used to deliver a kanamycin-resistance gene into sugarcane protoplasts in the late 1980s, marking the beginning of genetic transformation studies in the plant. It was possible to generate transformed plants via particle bombardment (biolistics) of cell suspensions and embryogenic calli using this method. The bar gene, which encodes phosphinothricin acetyltransferase, was used to produce plants that were resistant to the herbicide amonium-gluphosinate. This was accomplished via biolistics and the use of the bar gene. A microprojectile bombardment was used to stimulate meristematic tissues, and plants expressing the luciferase gene were grown from the seeds. Later, researchers published a method for the steady transformation of meristematic tissues that included the use of electroporation. A study published in Nature reported the growth of plants derived from the commercial cultivar NCo 310, which had the bar gene and had been altered via biolistics.

Recently, a number of research investigations have shown that the transformation of sugarcane by Agrobacterium–mediated and particle bombardment transformation is effective enough to provide marketable cultivars. Aside from that, through genetic transformation, many genes of economic relevance have been introduced into sugarcane, conferring herbicide tolerance, disease and insect resistance, drought tolerance, higher sucrose content, as well as increases in sugar quality and color. A genetically modified sugarcane plant has also been developed with the goal of utilizing the plant as a biofactory, generating high-value-added products such as bioplastics and high-value isomers of sucrose, among other things.

3. CONCLUSION

During the colonial era in Brazil, cachaça (also known as aguardente) manufacturing began, soon after sugarcane was brought into the Capitania de So Vicente in the 16th century and the first sugar mill was built in this area. Depending on the scale of production and the region in which they are produced, different names are given to cachaça production units. For example, industrial cachaça is produced in distilleries, artisanal (or boutique) cachaças that are created in northeastern Brazil are produced in engenhos, which are remnants of colonial times, and boutique cachaças that are created in southern and southeastern Brazil are produced in engenhos.

Cachaça is produced by distilling fermented sugarcane juice, and it has an ethanol level ranging between 38 and 54 percent by volume when stored at 20 degrees Celsius. After beer, cachaça is the most popular alcoholic beverage in Brazil, according to a recent study, with an average yearly consumption of seven liters per capta. Cachaça production is projected to be 1.3 billion litres, which mostly serves the domestic market due to the fact that exports account for less than 1 percent of overall output. Estimates suggest that there are about 30,000 cachaça manufacturing units spread across the nation. In addition to generating yearly sales of US$ 500 million, the activity also supports about 400,000 direct and indirect employment opportunities.

REFERENCES:

[1] A. Cheavegatti-Gianotto *et al.*, "Sugarcane (Saccharum X officinarum): A Reference Study for the Regulation of Genetically Modified Cultivars in Brazil," *Tropical Plant Biology*. 2011, doi: 10.1007/s12042-011-9068-3.

[2] I. Moreira and I. S. Scarminio, "Chemometric discrimination of genetically modified Coffea arabica cultivars using spectroscopic and chromatographic fingerprints," *Talanta*, 2013, doi: 10.1016/j.talanta.2013.01.053.

[3] S. E. Hannula, W. de Boer, and J. A. van Veen, "In situ dynamics of soil fungal communities under different genotypes of potato, including a genetically modified cultivar," *Soil Biol. Biochem.*, 2010, doi: 10.1016/j.soilbio.2010.08.020.

[4] E. C. Ng, N. T. Dunford, and K. Chenault, "Chemical Characteristics and Volatile Profile of Genetically Modified Peanut Cultivars," *J. Biosci. Bioeng.*, 2008, doi: 10.1263/jbb.106.350.

[5] Ö. Inceoğlu, J. F. Salles, and J. D. van Elsas, "Soil and Cultivar Type Shape the Bacterial Community in the Potato Rhizosphere," *Microb. Ecol.*, 2012, doi: 10.1007/s00248-011-9930-8.

[6] Q. Nguyen, N. Hettiarachchy, S. Rayaprolu, S. Jayanthi, S. Thallapuranam, and P. Chen, "Physicochemical Properties and ACE-I Inhibitory Activity of Protein Hydrolysates from a Non-Genetically Modified Soy Cultivar," *JAOCS, J. Am. Oil Chem. Soc.*, 2016, doi: 10.1007/s11746-016-2801-1.

[7] A. McHughen and S. Smyth, "US regulatory system for genetically modified [genetically modified organism (GMO), rDNA or transgenic] crop cultivars," *Plant Biotechnology Journal*. 2008, doi: 10.1111/j.1467-7652.2007.00300.x.

[8] S. J. Valencia-Cataño, J. Rodríguez-Chalarca, and C. A. Blanco, "Effect of genetically-modified cotton cultivars on demographic parameters of Spodoptera frugiperda1 in Colombia," *Southwest. Entomol.*, 2016, doi: 10.3958/059.041.0426.

[9] M. D. K. Owen *et al.*, "Comparisons of genetically modified and non-genetically modified soybean cultivars and weed management systems," *Crop Sci.*, 2010, doi: 10.2135/cropsci2010.01.0035.

[10] X. Qiu, A. Buentello, R. Shannon, A. Mustafa, A. Abebe, and D. A. Davis, "Evaluation of three non-genetically modified soybean cultivars as ingredients and a yeast-based additive as a supplement in practical diets for Pacific white shrimp Litopenaeus vannamei," *Aquac. Nutr.*, 2018, doi: 10.1111/anu.12545.