Saccharum officinarum L.

Pablo Florez

Agricultural Science

Colegio Bolivar

2018-2019

Wojciech Waliszewski

Image retrieved from (Kew science, 2018).

TABLE OF CONTENTS

1.0: Introduction

Saccharum Officinarum is a variety of the crop that is commonly known as sugarcane. It has been present in Colombia for over five hundred years, and it is now one of the most important industries for the economy in Valle del Cauca. This monograph is a detailed research about this crop, and it will address its ecology, biology, propagation and management, and emerging products and market. Ecology discusses matters such as its distributional contex, affinities, origin, ideal elevation and climate, geology and soils, and its vegetation components. The biology talks about the crop's chromosome complement, its life cycle, the process of flowering and fruiting, and reproduction. The chapter of propagation and management is based on how the crop is planted, how it should be managed, how does the crop propagate, and pest and disease control. The last section refers to emerging products and potential markets. Its main focus is discussing how from sugarcane multiple products rise, products such as alcoholic beverages, ethanol, sugar cane juice as a remedy, the production of cardboard and paper, and many other markets.

Chapter 2.0: Ecology

2.1 Distributional Context

2.1.1 Affinities

Saccharum officinarum, also known as sugar cane is a Poaceae grass that forms part of the *Saccharum* genus. It is a monocot that belongs to the Magnoliopsida class. This spermatophyte or seed plant also forms part of the division Tracheophyta (vascular plants) and to the super division of Embryophyta. The genus *Saccharum* has multiple species such as; *Saccharum atrorubens, Saccharum fragile, Saccharum glabrum, Saccharum hybridum, Saccharum infirmum, Saccharum luzonicum,Saccharum monandrum,* and *Saccharum officinarum* (‘ITIS Standard Report Page: Saccharum officinarum’, 2019). The species of *S.officinarum* also has multiple varieties including *Saccharum officinarum var:*

- brevi pedicellatum
- genuinum
- giganteum
- jamaicense
- litteratum
- luteum-durum
- otaheitense
- rubrum-altum
- tahitense

(‘ITIS Standard Report Page: Saccharum officinarum’, 2019).

2.1.2 Present Distribution and Origin

This perennial grass originated in New Guinea, 4000 B.C. When Alexander the Great visited India, he called sugarcane “a cane that produced 'honey' without the help of the bees.”

He spread it to western Europe, Borneo, Sumatra, and later on to the rest of Europe. Between 1400 and 1500, the Spanish and Portuguese conquerors brought it to South America. In his second trip to The Americas, Cristóbal Colón brought sugar cane to Colombia in 1492. In 1501, seeds were introduced to Santo Domingo, which then reproduced and spread along the Caribbean (Procaña, 2016). At the present time, *Saccharum officinarum* is produced and cultivated mainly in tropical countries, but it can also grow in subtropical zones. The United States Department of Agriculture presents data detailing countries with the biggest production rates (Table 1 below). :

Table 1: Production Rates Per Country. (Sugar: World Markets and Trade, United States Department of Agriculture) November 2018

1,000 Metric Tons, Raw Value

	2014/15	2015/16	2016/17	2017/18	May 2018/19	Nov 2018/19
Production						
India	30,460	27,385	22,200	34,110	33,830	35,870
Brazil	35,950	34,650	39,150	38,870	34,200	30,600
European Union	18,449	14,283	18,314	20,896	20,300	19,525
Thailand	10,793	9,743	10,033	14,710	14,100	13,800
China	11,000	9,050	9,300	10,300	10,800	10,800
United States	7,853	8,155	8,137	8,430	8,148	8,178
Pakistan	5,164	5,265	6,825	7,425	6,525	6,525
Mexico	6,344	6,484	6,314	6,371	6,386	6,386
Russia	4,350	5,200	6,200	6,500	6,400	6,100
Australia	4,700	4,900	5,100	4,800	4,800	5,000
Guatemala	2,975	2,823	2,719	2,788	2,700	2,700
Turkey	2,055	2,000	2,500	2,500	2,600	2,600
Egypt	2,067	2,125	2,270	2,320	2,435	2,435
Colombia	2,350	2,250	2,300	2,500	2,400	2,400
Ukraine	1,728	1,638	2,156	2,326	2,315	2,315
Philippines	2,150	2,135	2,500	2,100	2,300	2,225
Indonesia	2,100	2,025	2,050	2,100	2,200	2,200
South Africa	2,192	1,684	1,607	2,064	2,200	2,150
Iran	1,450	1,640	1,770	2,150	1,820	2,000
Argentina	2,150	2,060	2,050	1,810	1,820	1,820
Cuba	1,850	1,625	1,800	1,100	1,320	1,600
Vietnam	1,510	1,330	1,520	1,540	1,540	1,500
Peru	1,480	1,206	1,238	1,190	1,350	1,350
Japan	795	850	720	840	850	840
Nicaragua	695	662	733	787	800	800
Other	14,972	13,700	14,524	14,047	14,112	14,167
Total	177,582	164,868	174,030	194,574	188,251	185,886

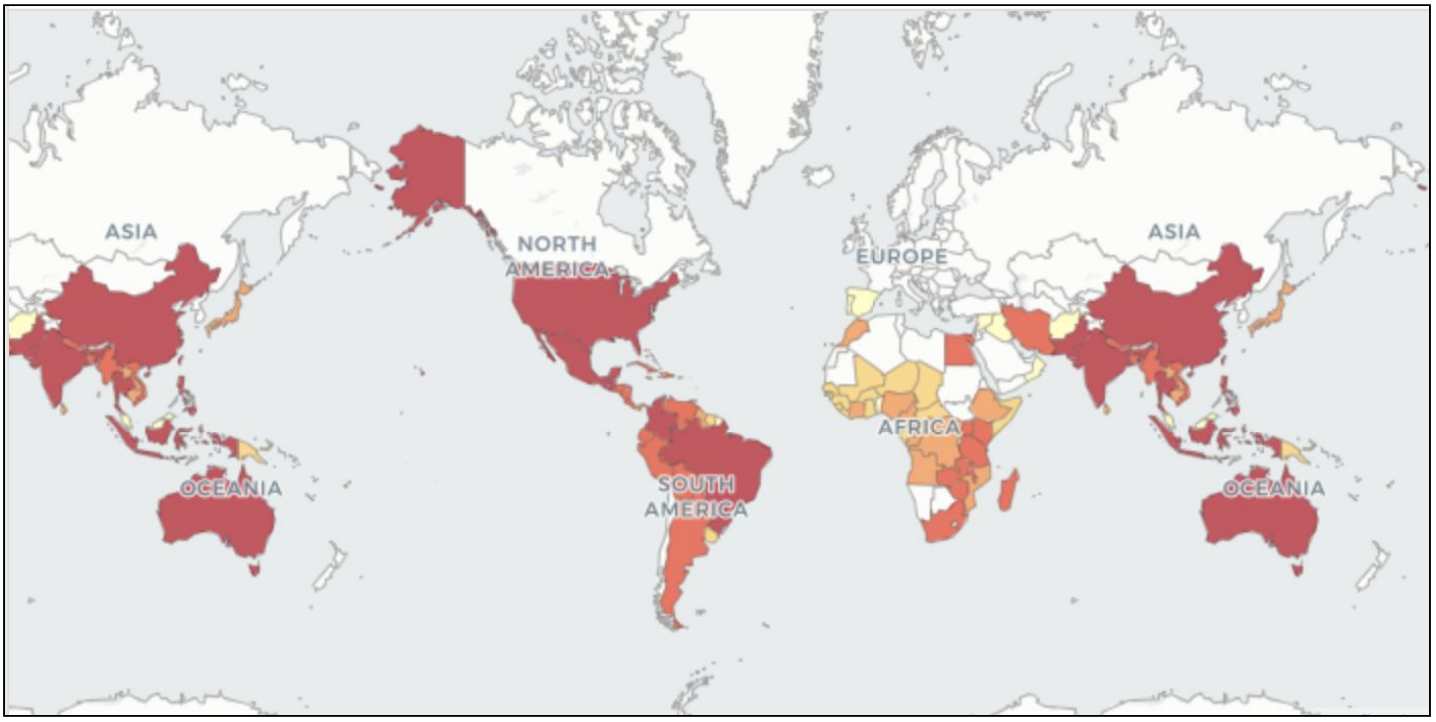


Figure 1: Sugar cane producing countries in 2017. The following map visualises all the countries that produce sugar cane, map generated by (FAOSTAT, 2017)

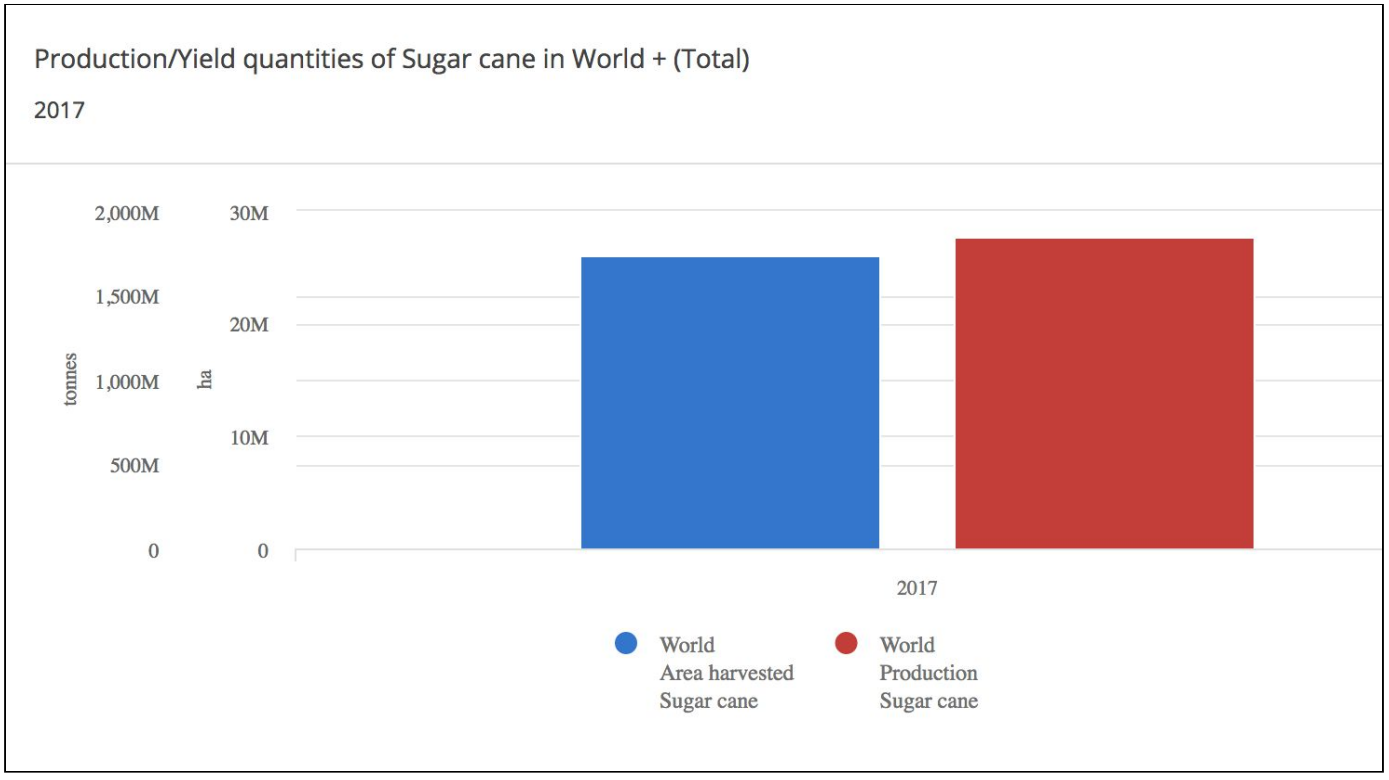


Figure 2: This chart reveals the world area harvested versus the world area *s.officinarum* production

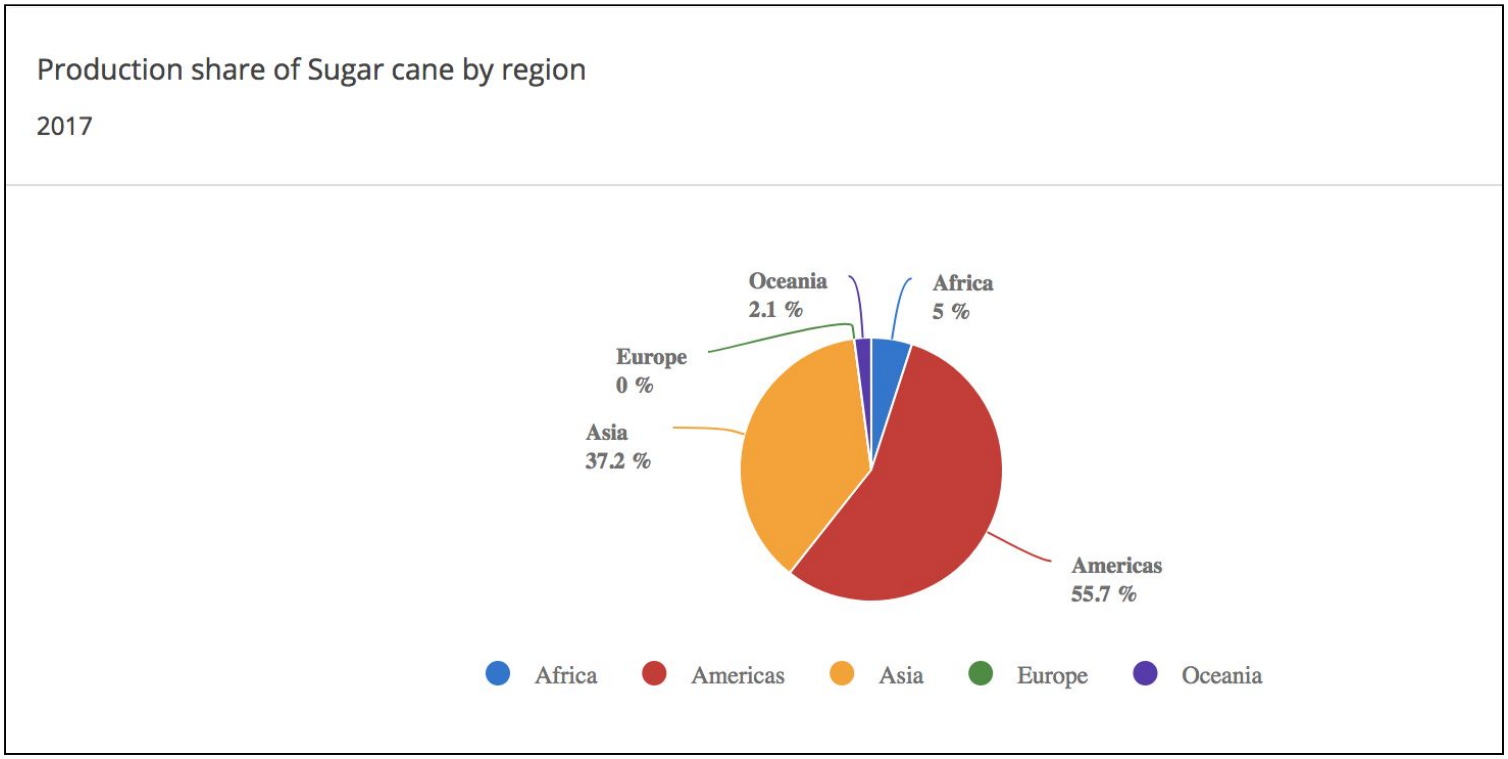


Figure 3: This chart shows the production percentage of each region

All graphs were obtained from (Food and agriculture organization of the United States, 2017).

Sugar cane is produced in over 70 countries in the World. In Asia, major sugarcane producing countries are Thailand, the Philippines, Indonesia, Malaysia and Papua New Guinea (Kuntohartono & Thijsse, 2018). India recently outnumbered Brazil's production, and these two countries are by far the highest producers. Countries such as Thailand and China also have high statistics. The European Union does not directly compete with the other listed countries because due to their temperatures, soil, and elevation, they have to use other species that are more resistant to all these characteristics. Colombia is the fourteenth largest producer and supplier of sugar cane, producing 2500 TMT (thousand metric tons) 2017-18. In Colombia, the seeds were first planted in el Valle del Cauca, 1541, by Sebastian de Benalcazar. 200 years later, multiple sugar producer companies such as Manuelita, Riopaila,

Providencia, Mayaguez and many other, bring more than 188,000 jobs to the region (Procaña, 2016).

2.2 Elevation and Climate

As all plants, *S. officinarum* species has optimal circumstances to grow in order to produce better quality and quantity. It grows best at tropical areas, but it also grows in subtropical zones. The optimal temperatures varies with the phase of growth the plant is in. During germination, the optimal temperature is between 26 and 33 degrees celsius, from 30 to 33 degrees for vegetative growth, and during maturation, in order to obtain high sucrose, it is essential to have lower temperatures close to 20 degrees celsius (Kuntohartono & Thijsse, 2018). Lower temperatures extend the time of growth, even though it increases the amount of sugar in each plant. The ideal altitude to grow sugar cane is between sea level and 1000 meters above sea level. Temperatures below 15 degrees would be harmful for the growth of the plant, so it is fittest to grow between latitudes of 35°N to 30°S (Fernando santos, 2015). An average rainfall of 1800-2500 mm per year is ideal. If this amount is not reached, water must be supplied by different types of irrigation (Kuntohartono & Thijsse, 2018).

2.2.1 Geology and Soils

Saccharum officinarum does not really need a specific type of soil to grow in, but there are certain nutrients and micro components that benefit the growth of the plant. Nitrogen, potassium, phosphorus are all essential and are inserted to the soil throughout fertilizers and other plants that release these, such as caupi frijol releases nitrogen, as well as urea. The amount of fertilizers used also vary in the ph of the soil. An ideal pH for *S.officinarum* to grow in is between 5 and 8 (Kuntohartono & Thijsse, 2018).

2.3 Vegetation Components and Interactions

Usually, sugar cane and other crops are intercropped with other plants that benefit their growth and maximize the crop's production. Many sugar cane growers in Valle del Cauca intercrop Sugarcane with Maize. This because when maize stopped to grow as much in the region, plagues such as *cogollo* and picudo that before attacked the maize, now were attacking the sugar cane. In order to avoid these plagues from affecting the sugar cane, maize is planted around the hectare (C.Izquierdo, Pers. com., 2018). Sugar cane is also intercropped with caupi frijol, since sugarcane needs nitrogen, and caupi releases the nitrogen it needs.
S. Kandaswamy and A.S. Tayade conducted a study about sugarcane intercropping systems and its effects.

Table 2: Compilation of experiments in study:

Study	Author	Location
Legume, provided soil fertility, release of nitrogens and residues achieved to beneficial relationship with *s.officinarum.*	Kailasam	Tropical india, 2008
Sunflower, but the results revealed a negative effect towards *s.officinarum growth*	Kathiresan and Rajasekaran	Tamil Nadu, 1990
Black gram, considering results is perceived as compatible	Kathiresan and Rajasekaran	Tamil Nadu, 1991
Sunnhemp, a improved the soil chemical properties to help sustain the cultivation of sugarcane.	Khandagave	2010

Research compiled revealed that the best seeds to intercrop with *s.officinarum* are legume, sunn hemp, and maize. These other crops provided more fertility and nutrients, this in order to maximize the production of sugar cane.

Chapter 3.0: Biology

3.1 Chromosome complement

Saccharum Officinarum is a diploid and consists of two groups of forty identical chromosome pairs (2n= 80). But other varieties such as *s.spontaneum* have multiple hybrids that are formed by 54, 56, 61, 63, 64, 80, 112, and 124 chromosome pairs. These other hybrids are generated in order to adapt the seeds to the environment they will be facing, obtaining results such as better resistance (Nair, 1975).

3.2 Life cycle

The life cycle of *Saccharum Officinarum* is consists of the following phases: planting, watering and care, seed production, harvesting, and replanting (Sharpe, 2017). Before planting respective fertilizers and nutrients must added to the soil in order to ensure peak production. Propagation is achieved by using seed canes from about four to six buds (Sachin & A.K, 2018). These canes are planted two inches into the soil and spread throughout rows, each row being apart by approximately 5 feet, and each seed cane separated by about 30 cm (Sharpe, 2017). These seeds must be watered enough so that these are moist. In areas that have less than 1500 mm of annual rainfall or unconstant climate, human irrigation must be applied (‘Introduction to Growing Sugarcane’, n.d.). Seeds take about a year to be ready for the first harvest . These seeds are maintained for three years, which then are replaced due to avoid production decline (Sharpe, 2017).

3.2.1 Flowering and fruiting

Seeds must have some environmental conditions in order to grow correctly and achieve best production. The optimal temperatures varies with the phase of growth the plant is in. During germination, the optimal temperature is between 26 and 33 degrees celsius, from 30 to 33 degrees for vegetative growth, and during maturation, in order to obtain high sucrose, it is essential to have lower temperatures close to 20 degrees celsius (Kuntohartono & Thijsse, 2018). Lower temperatures extend the time of growth, even though it increases

the amount of sugar in each plant. The ideal altitude to grow sugar cane is between sea level and 1000 meters above sea level. Temperatures below 15 degrees would be harmful for the growth of the plant, so it is fittest to grow between latitudes of 35°N to 30°S (Fernando Santos, 2015). The flowering and fruiting of *S. officinarum* is divided in the following phases; germination, tillering, grand growth, and maturation & ripening. For germination, it is propagated vegetatively by stem parts, which should have at least three buds. This phase lasts about 30-35 days (Kanchannainwal, 2009). The tillering phase initiated when the first sprouts start to appear (about 15 days). New sprouts constantly form in this phase, and a certain amount of stalks need to be produced in order for the crop to be considered effective (Ahmad, 2019). The grand growth phase is the longest. It lasts about 250-270 days, in which leaf production is rapid. Stalks also are in constant grow, and can reach 4-5 internodes per month (Figure 1, below). During this period of time, only 50% of the tillers survive (Netafim, 2013). Ripening and maturation takes place on the last three months of the year. Vegetative growth reduces during this phase, while sugar synthesis. Cane ripening starts at the bottom of the stalks and finishes at the top, therefore the bottom part has more cane sugar accumulation than the top (Netafim, 2013).

Figure 4: The image above shows what the stalks are, we can appreciate the internodes. These stalks are in constant growth, and 4-5 internodes per month appear while the sugarcane is in its grand growth phase. *Image retrieved from (Yadav, 2009).*

3.3 Reproductive biology

When the crop achieves a mature stage of development, it finishes its vegetative stage and initiates the reproductive stage. Thus, it stops production of leaf primordia and begins producing inflorescence. The inflorescence consists of an open-branched panicle, which has thousands of flowers. Each flower can produce one seed. Th seeds weigh about 250 per gram. A day of 13 hours and low night temperatures of about 20 degrees celsius will cause floral initiation (Netafim, 2013).

Image retrieved from (Netafim, 2013).

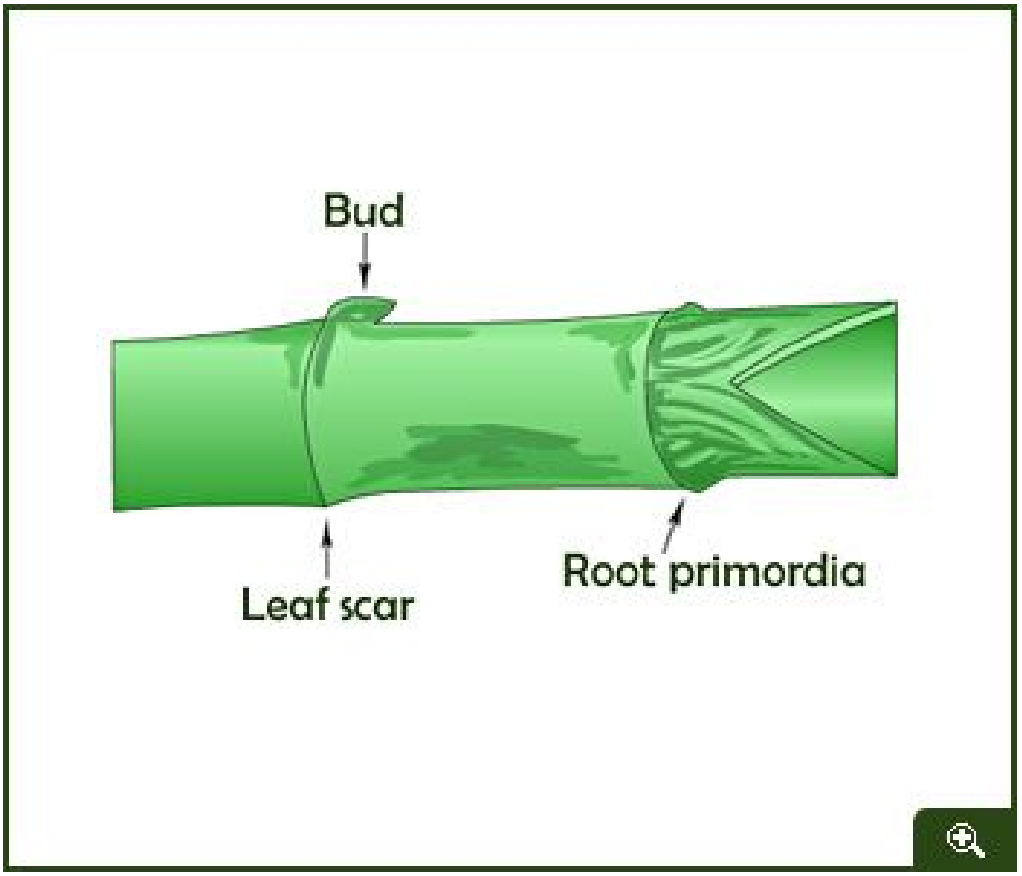
Figure 4: The image above is showing the open-branched panicles that spread tiny flowers, which lead the reproduction of the crop.

Chapter 4.0: Propagation and Management

4.1 Propagation

Saccharum officinarum is propagated with stem cuttings of the cane stalks. Each set has one or more buds. These are located in the root band of the node, are embryonic shoots of a miniature stalk with small leaves. Usually there is a bud on each node, and they alternate on one side of the stalk to the other. Characteristics of the buds such as size or shape determines different varieties. In ideal situations, the bud sprouts and the primary stalk is formed. A month after germination, the crop utilizes the reserves in the seed piece, also using water and nutrients that the first roots provide (Netafim, 2013).

Image retrieved from (Netafim, 2013).



4.2 Planting

The sowing is made of cane that is eight months old, cut into pieces of approximately 50 cm and in each of the internodes of the cane there is a bud, and that is where the new cane appears. Approximately after 45 days, mechanical fertilization is applied with eight packages of 50 kilos of Urea that has 46% nitrogen, two packages of phosphorus, and potassium are also applied. Usually, during the vegetative period, it is necessary to control unwanted weeds with chemicals (Carlos Izquierdo, Pers. comm. 2019). Due to different conditions such as weather, each country has a different season for planting new seeds:

Table 3: Planting seasons for top sugarcane producing countries (Netafim, 2013).

Country	***Planting Time***
Brazil	May-October or September-March
India	October-March or September-April
China	November to April
USA	August to March
Thailand	June-July or November
Philippines	October-May
Pakistan	February to March

4.3 Management

A batch or lot is sown every 6 or 7 years on average, the cane is cut (harvest) every 13.5 months. Every time the crop is cut, it is necessary to use subfloors and make a plowing to aerate the soil and counteract the compaction that the harvest went through with the harvesting machines. If the seed is taken care of, it can be perennial, so each time it is cut it

comes back and it is born, but because of the mechanization and pests, that seed has to be renewed every six or seven years. The issue of whether using “corteros” or machinery to harvest the crops has evolved in recent years. The use of corteros has reduced due to environmental issues, because if the lots are cut by people, it is necessary to burn, and this activity has been regulated and reduced by authorities. The use of machinery has also caused an incrementation of plagues in the crops, because these plagues attack to the machines, and these machines spread them around other lots. So, when the harvesting is done with machinery, it is not possible to burn. Therefore, approximately forty tons of leaves per hectare. These leaves must be organized within the lot every two rows, using an implement called “dispatcher” (Carlos Izquierdo, Pers comm. 2019).

A lot within the 13-month cycle is watered four or five times, each irrigation uses an average of 1200 m^3 per hectare. Additionally in the vegetative cycle of the sugarcane, in those 13 months it receives approximately 1,300 millimeters of rainfall. There are different types of irrigation, all focused on optimizing the efficient use of water. For example, at the highest place in the hectare, which are lots with a slope of more than 5%, window piping is used to which a small tube of half an inch is placed in each row to apply little water. This system is called reduced flow.

Image taken by Oscar Florez

Window piping irrigation system

The traditional irrigation system is done with open channels of water. Then it delivers this water to the main irrigation ditch, which is in the upper part of the lot. Gaps are opened in each of the rows so that water is able to flow. One of the most recent irrigation system surged in order to reduce water consumption. It consists of driving water through buried pvc pipes with deep well water, and window piping is placed inside the lot. This way, it is possible to reduce water consumption by almost 50% because there are no losses in driving.

This next irrigation system consists of using rubber hoses with extremely small holes. These hoses are placed in between each row, while they sprinkle water to the crop. This system has many benefits, it achieves to save the most amount of water. It is also ideal to use in lots where the seeds have been renewed after six years. The soil is very loose and using other irrigation systems would not let it compact due to excess of water (Carlos Izquierdo, Pers. comm. 2019).

Image taken by Oscar Florez

Sprinkle irrigation system

Image retrieved from (Pakistan Agriculture Research, 2019).

Figure 5: After ripening and maturation comes to an end, after a process of approximately twelve months, it is time to harvest the crop. In the previous image, we can see how people manually harvest the sugar cane. This method takes longer than others, but these people do a more precise job than a machine due to their experience and judgement.

Image retrieved from (Strachan, 2013).

Figure 6: In this image we can see another method for harvesting, which is multiple times faster than the "corteros" but it is not nearly as precise as them. That is a very controversial topic for sugarcane growers in Valle del Cauca. Because hiring people to harvest brings many job opportunities for people that need one, even if they receive minimum wage payments. But machinery is faster, and that is a very big benefit.

The crop must have some environmental conditions in order to grow correctly and achieve best production. The optimal temperatures varies with the phase of growth the plant is in. During germination, the optimal temperature is between 26 and 33 degrees celsius, from 30 to 33 degrees for vegetative growth, and during maturation, in order to obtain high sucrose, it is essential to have lower temperatures close to 20 degrees celsius (Kuntohartono & Thijsse, 2018). Lower temperatures extend the time of growth, even though it increases the amount of sugar in each plant. The ideal altitude to grow sugar cane is between sea level and 1000 meters above sea level. Temperatures below 15 degrees would be harmful for the growth of the plant, so it is fittest to grow between latitudes of 35°N to 30°S (Fernando Santos, 2015). The flowering and fruiting of *S. officinarum* is divided in the following phases; germination, tillering, grand growth, and maturation & ripening. For germination, it is propagated vegetatively by stem parts, which should have at least three buds. This phase lasts about 30-35 days (Kanchannainwal, 2009). The tillering phase initiated when the first sprouts start to appear (about 15 days). New sprouts constantly form in this phase, and a certain amount of stalks need to be produced in order for the crop to be considered effective (Ahmad, 2019). The grand growth phase is the longest. It lasts about 250-270 days, in which leaf production is rapid. Stalks also are in constant grow, and can reach 4-5 internodes per month (Figure 1, below). During this period of time, only 50% of the tillers survive (Netafim, 2013). Ripening and maturation takes place on the last three months of the year. Vegetative growth reduces during this phase, while sugar synthesis. Cane ripening starts at the bottom of the stalks and finishes at the top, therefore the bottom part has more cane sugar accumulation than the top (Netafim, 2013).

4.3.2 Pest and disease control

Saccharum officinarum has a wide variety of pests and diseases that affect its growth and development. These include the early shoot borer, internode borer, top borer, scale insect, pyrilla, termites, white fly, red rot, smut, wilt, ratoon stunting disease, leaf scald, yellow leaf spoot, and others (Netafim, 2013).

The early shoot borer causes yield loss, poor juice quality, cane weight reduction. This disease attacks the crop before internode formation, in early cane growth. This happens when larvae enter the canes through holes in the stalks, and then bores around until killing the growing point (Netafim, 2013).

The internode borer attacks the crop later on the growth stage, right after internode formation and maintains until harvest. This disease also causes juice quality reduction and yield loss when the infestation is significant. This disease consists of larvae feeding and multiplying in water shoots. Each larvae can damage up to 3 internodes per cane (netafim, 2013).

Sugarcane with Maize. This because when maize stopped to grow as much in the region, plagues such as *cogollo* and picudo that before attacked the maize, now were attacking the sugar cane. In order to avoid these plagues from affecting the sugar cane, maize is planted around the hectare (C.Izquierdo, Pers. com, 2018).

Chapter 5.0: Emerging Products and Potential Markets

5.1 Emerging products and potential markets

Sugarcane and its waste are used in many products and have a place in many markets around the world. Sugar, ethanol, alcoholic beverages, gasoline, wax, paper, and cardboard. Wastes like bagasse, molasses, and reeds also have multiple uses such as making pens, mats, fuel, and food for cattle (Duke, 1998).

Table 4: Production Rates Per Country. (Sugar: World Markets and Trade, United States Department of Agriculture) November 2018.

1,000 Metric Tons, Raw Value						
	2014/15	2015/16	2016/17	2017/18	May 2018/19	Nov 2018/19
Production						
India	30,460	27,385	22,200	34,110	33,830	35,870
Brazil	35,950	34,650	39,150	38,870	34,200	30,600
European Union	18,449	14,283	18,314	20,896	20,300	19,525
Thailand	10,793	9,743	10,033	14,710	14,100	13,800
China	11,000	9,050	9,300	10,300	10,800	10,800
United States	7,853	8,155	8,137	8,430	8,148	8,178
Pakistan	5,164	5,265	6,825	7,425	6,525	6,525
Mexico	6,344	6,484	6,314	6,371	6,386	6,386
Russia	4,350	5,200	6,200	6,500	6,400	6,100
Australia	4,700	4,900	5,100	4,800	4,800	5,000
Guatemala	2,975	2,823	2,719	2,788	2,700	2,700
Turkey	2,055	2,000	2,500	2,500	2,600	2,600
Egypt	2,067	2,125	2,270	2,320	2,435	2,435
Colombia	2,350	2,250	2,300	2,500	2,400	2,400
Ukraine	1,728	1,638	2,156	2,326	2,315	2,315
Philippines	2,150	2,135	2,500	2,100	2,300	2,225
Indonesia	2,100	2,025	2,050	2,100	2,200	2,200
South Africa	2,192	1,684	1,607	2,064	2,200	2,150
Iran	1,450	1,640	1,770	2,150	1,820	2,000
Argentina	2,150	2,060	2,050	1,810	1,820	1,820
Cuba	1,850	1,625	1,800	1,100	1,320	1,600
Vietnam	1,510	1,330	1,520	1,540	1,540	1,500
Peru	1,480	1,206	1,238	1,190	1,350	1,350
Japan	795	850	720	840	850	840
Nicaragua	695	662	733	787	800	800
Other	14,972	13,700	14,524	14,047	14,112	14,167
Total	177,582	164,868	174,030	194,574	188,251	185,886

Table 4: The table above reveals the top sugarcane producing countries, measured in million metric tons. India and Brazil are in constant competition for the highest production rate. India is estimated to produce 35.5 million tones in 2018-2019, which would break the record of 34 million tons set by Brazil. India will pass Brazil as the biggest sugar producing country, but Brazil does surplus sugarcane stocks to produce ethanol through out fermentation, thing that India does not do (Dry Cargo Magazine, 2018). The European Union follows behind because it is significantly bigger. Colombia is in fourteenth position because the only place that sugarcane is grown at a big scale is Valle del Cauca. We can notice that all of these countries follow the climatic conditions and are close to ideal environment to grow sugarcane. Even though these vary, other seeds that have more resistance towards issues present in the area are planted so that crops are not affected (United States Department of Agriculture, 2019).

5.1.2 Saccharum officinarum Products

Saccharum officinarum is mainly used to produce sugar and ethanol, where sugar cane goes through different processes to achieve the generation of these industrialized products. Ethanol is a fuel based on alcohol, which is produced by the fermentation of sugar juice and molasses. By adding oxygen to gasoline, ethanol achieves to reduce air pollution. In some cases it is mixed with gasoline in order to reduce tailpipe emissions. It is also used in its pure state, but only certain engines are apt for use (Sugarcane.org, 2016). As for sugar, it is obtained from sugarcane processing, which consists of 99.8% sucrose. Raw sugar is dissolved, insoluble material and colorants are removed to obtain white sugar (Cheavegatti-Gianotto et al., 2011). *S. Officinarum* is also used to produce cane sugar, molasses, rum, wax, and cane syrup. Molasses are often used as food sweeteners, in combustion engines, in industrial alcohol and also for explosives. As tradition in Valle del Cauca dictates, fresh cane stems are chewed due to their sweet taste. Sugar is also used as a preservative for meats and fruits. Bagasse, a product of sugarcane processing is used to manufacture paper, cardboard, and fuel. Molascuit is a mixture of bagasse and molasses is used to feed cattle (Duke, 1998).

5.1.3 Alcoholic Beverages

Basi, aguardiente, rum and cachaca are one of the most common beverages made from sugarcane. Basi and aguardiente are made from sugar cane juice. Basi is originated from the Philippines and aguardiente is mainly produced in Ecuador and Colombia (Salucop, 2014). Cachaca is made from sugar cane juice extracted from stalks, which is fermented and then distilled (Liquor, 2017). Rum is made from molasses, a component extracted while the processing of sugar cane (Ministry of Rum, 2019).

Image retrieved from (Whisky and More, 2019).

Figure 7: Traditional Cachaca liquor produced in Brazil

5.1.4 Medicinal Uses

Sugarcane juice due to its richness in antioxidants is a mayor immunity booster, and its abundance of electrolytes avoid dehydration. It is a diuretic, which means it helps treat issues such as tract infections or kidney stones, while it achieves to assure proper kidney functioning. It also helps to strengthen your liver, which helps cure health issues such as jaundice, because it restores protein and nutrient loss. Due to its richness in carbohydrates, protein, iron, potassium and other essential nutrients, it helps counter attack fatigue when having harsh physical efforts or high temperature exposure. It has alkaline properties, thus it helps with treating acidity.It has a low glycemic index, therefore it does not alter blood glucose levels and is ideal for people that suffer diabetes. Its abundance in minerals helps prevent tooth decay (Malik, 2018).

Image retrieved from (Ikigai, 2017).

Figure 8: In this image we can see how sugarcane juice is extracted from cane stems. This is an old machine, but there are more industrial versions of it. This machine is used to obtain what is called "guarapo" here in Valle del Cauca.

5.2 Imports and Exports

Sugar exports in 2018 summed up to US$21.1 billion, which has gone down significantly in the past few years, dropping by 21.9% since 2014. The industry is going downhill, the value of globally exported sugar fell by 29% from 2017 to 2018. Refering to World's Top Exports, " *Among continents, Latin America (excluding Mexico) plus the Caribbean accounted for the highest dollar value worth of sugar exports during 2017 with shipments amounting to $14.3 billion or 51.8% of global sugar shipments. European countries were responsible for 19.5% followed by Asian suppliers at 18.1%. Smaller percentages came from Africa (7%), North America excluding Mexico (2.9%) and Oceania led by Australia (0.7%)"* (Workman, 2019).

Table obtained from (Workman, 2019)

Table 5: 10 countries that exported the highest dollar value worth of sugar during 2018

Country	***Total sugar exports***
Brazil	US$6.5 billion (30.9% of total sugar exports)
Thailand	$2.6 billion (12.3%)
France	$1.4 billion (6.5%)
India	$919.2 million (4.4%)
Germany	$800.8 million (3.8%)
Mexico	$712.8 million (3.4%)
Belgium	$542 million (2.6%)
Netherlands	$480.8 million (2.3%)
Guatemala	$478.7 million (2.3%)
Pakistan	$386.4 million (1.8%)

References

Ahmad, T. (2019, March 5). Morphology of Sugarcane & critical growth stages. Retrieved 2 May 2019, from Technology Times website: https://www.technologytimes.pk/morphology-sugarcane-growth-stages/

Australian Government. (2004). *The Biology and Ecology of Sugarcane (Saccharum spp. hybrids) in Australia*. 31.

Cheavegatti-Gianotto, A., de Abreu, H. M. C., Arruda, P., Bespalhok Filho, J. C., Burnquist, W. L., Creste, S., … César Ulian, E. (2011). Sugarcane (Saccharum X officinarum): A Reference Study for the Regulation of Genetically Modified Cultivars in Brazil. *Tropical Plant Biology*, *4*(1), 62–89. https://doi.org/10.1007/s12042-011-9068-3

Dry Cargo Magazine. (2018, September 4). India set to become World's largest sugar producer. Retrieved 5 June 2019, from https://www.drycargomag.com/india-set-to-become-worlds-largest-sugar-producer

Duke, J. A. (1998). Saccharum officinarum. Retrieved 10 January 2019, from https://hort.purdue.edu/newcrop/duke_energy/Saccharum_officinarum.html#Distribution

FAO. (2007). Saccharum Officinarum. Retrieved 28 November 2018, from http://ecocrop.fao.org/ecocrop/srv/en/cropView?id=1884

Fernando santos. (2015). Saccharum. Retrieved 20 December 2018, from https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/saccharum

Food and agriculture organization of the United States. (2017). FAOSTAT Sugar cane. Retrieved 13 January 2019, from http://www.fao.org/faostat/en/#data/QC/visualize

Hardev S. Sandhu, M. P. S. (2016, February 3). Sugarcane Botany: A Brief View. Retrieved 6 June 2019, from https://edis.ifas.ufl.edu/sc034

Ikigai, G. (2017). *Sugar Cane Juice Machine, Raw Video de stock (totalmente libre de regalías) 1010350751 | Shutterstock*. Retrieved from https://www.shutterstock.com/video/clip-1010350751-sugar-cane-juice-machine-raw-sugarcane-processed

Workman, D. (2019, April 20). Sugar Exports by Country. Retrieved 8 June 2019, from World's Top Exports website: http://www.worldstopexports.com/sugar-exports-country/

Introduction to Growing Sugarcane. (n.d.). Retrieved 11 March 2019, from Smart Fertilizer Management website: https://www.smart-fertilizer.com/articles/guide-to-growing-sugarcane

ITIS Report. (2019, January 10). ITIS Standard Report Page: Saccharum officinarum. Retrieved 10 January 2019, from https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=42058#null

Kanchannainwal, S. (2009, August 4). Sugarcane growth stages | agropedia. Retrieved 2 May 2019, from http://agropedia.iitk.ac.in/node/2647

Kandaswamy, S. (n.d.). (PDF) SUGARCANE BASED INTERCROPPING SYSTEM AND ITS EFFECT ON CANE YIELD. Retrieved 4 April 2019, from ResearchGate website: https://www.researchgate.net/publication/318760781_SUGARCANE_BASED_INTERCROPPING_SYSTEM_AND_ITS_EFFECT_ON_CANE_YIELD

Kewscience. (2018). Saccharum officinarum L. | Plants of the World Online | Kew Science. Retrieved 3 June 2019, from Plants of the World Online website: http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:419977-1

Kimberly, S. (2017, September). The Life Cycle of a Sugarcane Plant. Retrieved 5 March 2019, from Garden Guides website: https://www.gardenguides.com/99641-life-cycle-sugarcane-plant.html

Kuntohartono, T., & Thijsse, J., P. (2018, November 12). Saccharum officinarum (PROSEA). Retrieved 20 December 2018, from https://uses.plantnet-project.org/en/Saccharum_officinarum_(PROSEA)

Liquor. (2017). Everything You Need to Know About Cachaça. Retrieved 3 June 2019, from Liquor.com website: https://www.liquor.com/spirit/cachaca/

Malik, K. (2018, August 23). 6 Health Benefits of Sugarcane Juice: A Promise of Good Health. Retrieved 4 June 2019, from NDTV Food website: https://food.ndtv.com/health/6-health-benefits-of-sugarcane-juice-a-promise-of-good-health-1270503

Ministry of Rum. (2019). Sugar & Molasses - Ministry of Rum. Retrieved 3 June 2019, from http://www.ministryofrum.com/article_sugar_and_molasses.php

Nair, M. K. (1975). Cytogenetics of Saccharum Officinarum L. and S. Spontaneum L. IV. Chromosome Number and Meiosis in S. Officinarum X S. Spontaneum Hybrids. *Caryologia*, *28*(1), 1–14. https://doi.org/10.1080/00087114.1975.10796591

Netafim. (2013a). Crop Growth Phases. Retrieved 3 May 2019, from http://www.sugarcanecrops.com/crop_growth_phases/grand_growth_phase/

Netafim. (2013b). Pests and Diseases. Retrieved 6 June 2019, from http://www.sugarcanecrops.com/agronomic_practices/pests_diseases/

Netafim. (2013c). Planting Time. Retrieved 6 June 2019, from http://www.sugarcanecrops.com/agronomic_practices/planting_time/

Netafim. (n.d.). Propagation. Retrieved 6 June 2019, from http://www.sugarcanecrops.com/growth_morphology/propagation/

Pakistan Agriculture Research. (2019). Sugarcane Harvesting in Pakistan | Pakistan Agriculture Research. Retrieved 6 May 2019, from https://par.com.pk/sugar/crop-management/harvesting

Procaña. (2016, December). Historia de la Caña. Retrieved 4 December 2018, from https://www.procana.org/new/quienes-somos/historia-de-la-cana-de-azucar.html

Sachin, N., & A.K, M. (n.d.). (PDF) SUGARCANE PLANTING TECHNIQUES: A REVIEW. Retrieved 11 March 2019, from ResearchGate website: https://www.researchgate.net/publication/322976767_SUGARCANE_PLANTING_TECHNIQUES_A_REVIEW

Salucop, S. (2014). Aside from rum, what other alcoholic drinks could be made out of sugar cane? - Quora. Retrieved 3 June 2019, from https://www.quora.com/Aside-from-rum-what-other-alcoholic-drinks-could-be-made-out-of-sugar-cane

Sheth, K. (2017, April 25). Top Sugarcane Producing Countries - WorldAtlas.com. Retrieved 11 January 2019, from https://www.worldatlas.com/articles/top-sugarcane-producing-countries.html

Strachan, S. (2013, July 17). Farmers urged to plant sugarcane to cash in on demand. Retrieved 6 May 2019, from Gympie Times website: https://www.gympietimes.com.au/news/rural-sweetener-eyes-gympie-sugarcane-asia-demand/1947624/

Sugarcane.org. (2016). Ethanol - SugarCane. Retrieved 5 May 2019, from Ethanol - SugarCane website: sugarcane.org/ethanol/

sugar.pdf. (n.d.). Retrieved from https://apps.fas.usda.gov/psdonline/circulars/sugar.pdf

The Biology and Ecology of Sugarcane (Saccharum sp.pdf. (n.d.). Retrieved from http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/sugarcane-3/$FILE/biologysugarcane.pdf

theagricos.com | Scientific Classification – Sugarcane. (n.d.). Retrieved 28 November 2018, from http://theagricos.com/agriculture/crops/sugarcane/scientific-classification-sugarcane/

Whisky and More. (2019). Cachaca 51 700ml. Retrieved 4 June 2019, from Whisky and More website: https://www.whiskyandmore.co.nz/products/buy-cachaca-51-700ml-online

Yadav, K. (2009, August 13). Revision of BOTANICAL DESCRIPTION: SUGARCANE. Retrieved 6 May 2019, from http://agropedia.iitk.ac.in/node/2749/revisions/3668/view

Yamane, T. (n.d.). Sugarcane | plant | Britannica.com. Retrieved 27 November 2018, from https://www.britannica.com/plant/sugarcane