SUGAR CANE CULTIVATION

AND

SUGAR MANUFACTURE & LABORATORY ANALYSIS

By

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DEDICATED TO

MY

EVERLOVING PARENTS

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ABSTRACT

Sugar cane plays a key role in the plant kingdom of the world. Sugar cane has become a lucrative crop that is cultivated in many parts of the world. The growth and the yield of the sugar cane is depended upon several factors, such as environmental, cultural and mechanical factors. The higher quality of cane juice gives a good production of sugar. In terms of the soil its p^H value, moisture level, soil structure, nutritional condition, temperature and the drainage of the soil influence on the growth and yield of the cane. In addition, problems of pests and diseases, prosperous growth of weeds, natural factors including wild animals like elephants affect adversely on the cane cultivation. The suitable method of land preparation, planting system, irrigation methods, control of pest, diseases and weed, in the cultivation practise should be done in a time.

Considering the juice of cane, "Brix" and "Pol" values are the two important indicators used in the processing section and in the quality management section. High percent of sugar is produced, if the "Brix" and "pol" values are more than 16 and 75 respectively. The cane feeding, milling, purification, evaporation, crystallization and bagging are the six major steps in the manufacture of sugar.

The molasses, filter mud and bagasse are the 3 major by-products of the processing sugar. They are used for several purposes as fertilizer, fuel and the raw material for the production of alcoholic beverages.

The laboratory analyses are of primary importance in the quality controlling achievements. Each and every stages of processing is tested in the laboratory with the help of sampling to produce good quality of products.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Sugar cane is an important commercial crop in so many countries. In sugar cane plantain major objective is to extract sugar. Sugar is a main source of energy for human. It is the cheapest form of such energy giving food produced in a crop per unit of land. It has been estimated that the energy value of 1,000,000 calories which is required in an average man's annual food consumption could be produced from about one eighth acre of sugar cane. Against this rice requires 6 times and whole wheat flour 5 times as much land to produce the same amount of energy.

In the cooler temperate climatic regions sugar cane does not thrive. Sugar beet is grown for the production of sugar. The present annual production of sugar from both these crops is in the region of 107 million tons of this the contribution made by sugar cane is around 70%.

The unit consumption of sugar differ from country to country. In Sri Lanka the annual consumption is over 300,000 tons or 19 Kg per head. This is lower than a highly developed country like the USA where it is over 40 Kg per head. However the consumption in Sri Lanka is higher than in many developing countries.

The annual production i Sri Lanka has been around 25000 tonnes until 1985 with the commissioning of the two new factories at Sevenagala and Pelwatta there is now potential for the annual production to increase upto about 100,000 tonnes. This will be imported in 1989 the total production was 53894 times with Pelwatta producing more than half of it. The value of the sugar imported annually is around Rs. 4,000,000,000.

Sugar cane first introduced by dutch people it is planted in "Gingaga mitiyawatha" Baddegama in Galle district but there produce jaggery and sugar syrup sofar.

1.1 The factory efficiency is shown as follows.

Highest tonnage of cane	Mill per day	4142 MT
Highest tonnage of cane	Milled per week	23476 MT
Manufactured sugar	In week	2121 MT
Highest amount of bagged	Sugar per day	391.5 J
The amount of dropping	Pans per day	34000 MT
Removed bagases	In week	560 T
Supplement the electricity	In PSI	2 MV

Pelwatta Sugar Industries Ltd is the largest sugar producer in the country. The company was incorporated in Sri Lanka on 19th February 1981 as a private company and was subsequently converted to a public limited company on 10th December 1982.

In keeping with the declared aim of the Government of Sri Lanka to make the country self sufficient in sugar a solid bank study was under taken in 1978 to identify various areas in the Moneragala district of Sri Lanka which would be suitable for rainfed sugar cane cultivation.

Booker Tate Ltd- BTL (formerly known as Booker Agriculture International Ltd.) were invited to carry out a detailed feasibility study and the report was submitted in 1986. The conclusion of the study was that a viable sugar estate could be established at Pelwatta and thus was accepted by Government of Sri Lanka. Company on the 30th December 1981. Booker Agriculture International Ltd. were appointed as corporate managers to designate and to implement the project.

Pelwatta sugar Industries ltd. is the largest sugar producer in the country. The company was quoted in the Colombo Stock Exchange in 1984 and had it's first public share issue on 14th March 1984.

The project is located in the Moneragala district or Uva province about 225 Km by east of Colombo near the intersection of the A_4

East-West high way and the A_2 high way linking the South coast wit the highlands. Travelling time by road to Colombo is approximately five hours.

The estate lies on the boundary of the intermediate and dry rainfall zones of Sri Lanka, immediately South East of the central mountain massif at an altitude of 175 m above sea level.

The soils are mainly well drained reddish-brown earths on the higher ground with low humic glay and alluvial soils along the river. Of course the total acre surveyed over 9000 ha of land suitable for cane cultivation has been identified within the project area.

The Pelwatta sugar industries produce plantation white sugar. The rated capacity of the factory was increased from 47000 tonnes per year to 60000 tonnes through a factory expansion programme in 1992 and 1993.

The management contract with Booker trate limited (UK) expired on 31st December 1993 and Guangdony International Economic and Technical corporation of China were appointed corporate managers with effect from 1st January 1994.

The factory is supplied with cane from three main sources. A company managed Nucleus Estate of 2700 ha a settlement estate of 3600 ha where 1500 settler families are growing cane as a commercial crop for sale to the company/factory.

Pelwatta sugar Industries Ltd has a work force of around 1300 permanent employees over 3000 addition workers are also employed on a casual basis.

The objective of our project was observe procedures related to cultivation crop management, harvesting, laboratory analysis and sugar manufacturing process.

CHAPTER II

LITERATURE REVIEW

2.1 Taxonomy

Sugar cane is a giant grass. The genes saccharum is commonly known as a sugar cane,include both the cultivated and wild species.

Kingdom	-	Plantae
Division	-	Angiospermae
Class	-	Monocotyledonae
Family	-	Gramineae
Tribe	-	Andropogoneae
Genes	-	Saccharum
Species	-	Saccharum officinarum

The confirmed Saccharum species are :-

* Saccharum spontaneum

It is 'wild cane'. It has a thin stalked, hardy species resistant to diseases and pest and which is able to complete successfully in the wild. It is widely distributed throughout the Pacific Island, Asia and North-East Africa.

* Saccharum robustum

It is the second 'wild, type cane is restricted to New Guinea and neighboring Islands. This is a large, bamboo-like plant, often reaching 10 m in height, which is used for house and fence pests. This species, too has a high degree of resistance to pest and diseases attack.

* Saccharum officinarum

It is 'Noble cane', probable derived from S.robustum. These are

thick stalked canes, often with colourful longitudinal stripes on the stalk, 3-5 meters in height with few tillers. It is a high sucrose content and soft rind. It was the original soft sweet tasting chewing cane and varieties of this species are used earliest sugar production industries. This variety eventually

subjected to the damage of narrow of pests and disease, if any 'Noble cane' is now grown for commercial sugar production. In many countries 'Noble cane' is sold as 'eating cane' in local market.

* Saccharum barber

This species are be leaved to have arisen in North India as a hybrid between S.spontanaum and S.officinarum. Sugar was first manufactured from canes of this species. These are thin stalked, hardy canes suited to semi-tropical and temperate climates.

* Saccharum sinense

One variety 'Uba', achieved prominence about 100 years ago, when it replaced the disease susceptible 'noble cane' in many sugar industries. These are tall, vigorous, hardy canes which arose, again from hybridization between, S.spontaneum and S. officinarum.

2.2 Morphology of Sugar cane

In sugar cane, the morphology characters of the stem, root and leaf have been extensively studied by Barber, 1919 in India; Jeswiet, 1940 in Java and Artschwager (1925; 1939; 1940) in the U.S.A. They have all emphasized the diagnostic value of these characters in identifying the original species and also the hybrid varieties of sugar cane.

Sugar cane plant has 3 major parts namely, stem, leaf and root.

2.2.1 Stem

The sugar cane plant has a long, jointed stalk also called the **culm of stem.** A small portion of the basal stalk remains underground and this is known as **rhizome or root-stock**
Roots emerge from this basal portion. Bud, leaves and vegetative and reproductive structures develop on the above ground portion of the stalk.

The stalk (bearing nodes and internodes) is covered with a layer of wax, except in the region of the growth ring (Artschwager,1930 ; Barnes, 1964). The amount of wax is vary with varieties. The wax is deposited in the form of white and densely crowded rods, changing to black when mould grow on it (Dillewiji, 1952).
The stem consist with nodes internodes, varying in number, length and thickness in different genotypes of sugar cane. The shape of the internode is also vary with different varieties.
The stalk varies in high from 2 to 6 meters, depending on variety and growing conditions.

The length of internode may vary between 10 and 25 cm. Sometimes, short internodes are produced due to the adverse growth conditions, such as winter, drought and stalk injury. **The shape of the internodes** may be cylindrical, tumescent, bobbin, conoidal, obconoidal or concavo-convex (Barnes, 1964).

The colour of the rind (outer covering of the stalk) varies in young and old internodes and usually whitish-green, yellow,green, red or purple due to the presence of two pigments, namely anthocyanin and chlorophyll (Dillewijin, 1952). Anthocyanin is present in he epidermal and sub-epidermal layers, whereas chlorophyll is present in the deeper tissues. When the content of anthocyanin is more, the colour is red; but when there is more chlorophyll, the colour is green; when the both pigments are present in equal amount, the colour is purple; when the both pigments are absent, the colour is yellow. The node is

differentiated into four parts.namely, the leaf scar, root band, growth ring and bud. (Figure 2.1)

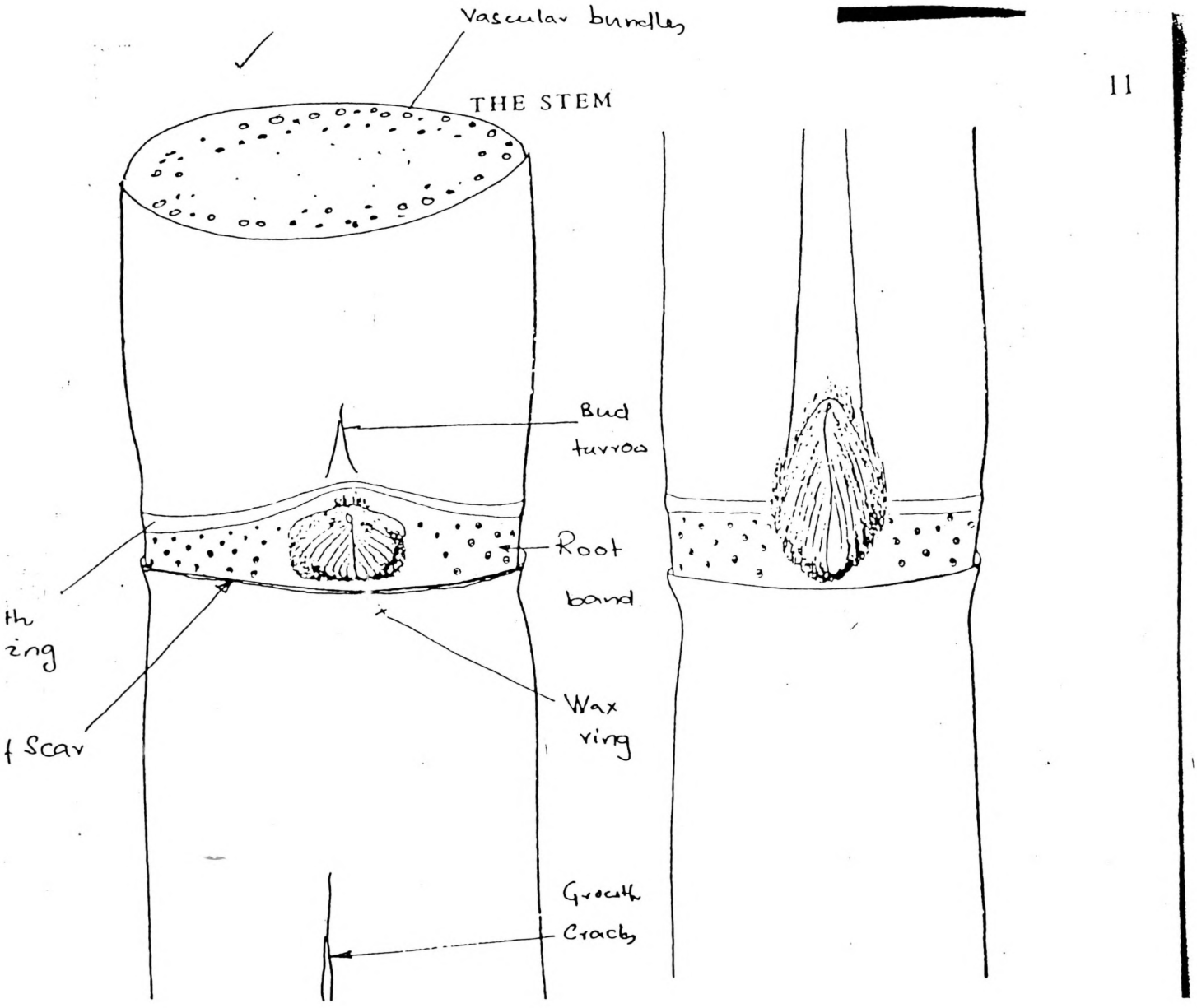


Figure 2.1 Stem of sugar cane

The leaf scar is that portion of the stalk to which the leaf sheath is attached.

The root band is situated just above the leaf scar and contains the root primordia or root eyes, their number vary with varieties.

The growth ring is a narrow band, that can be found just above the root band. It is responsible for the elongation of node and separates a node from an internode. It has no wax covering and its colour is always different from that of the internode.

The buds are an embryonic shoot and is situated at the node or slightly above it, to form a cushion. Normally one bud is present at each node, but occasionally two or multiple buds may be present. Infrequently, nodes without buds (blind node) have also been observed in nature. A bud may be small or big, long or short. It may be ovate, obovate, round, oval, triangular, pentagonal, rhomboid, rectangular or beaked. The characters of the buds are of great diagnostic value in the classification of canes.

2.2.2 Leaf

Each node bears a leaf and the leaves are arranged alternately on the stalk. It is include 3 major parts, namely leaf sheath, leaf blade, leaf margin.

The leaf sheath is attached to the stem at the node and it completely encircles with over lapping. Higher up, the edges separate a little exposing a part of the stem. The outer surface is green or purple and is often hairy or spiny, whereas the inner surface is whitish and glabrous. There is no mid-rib but widely spaced parallel veins are present.

The leaf blade may be broad or narrow, varying in width from 2.5 to 7.5 cm and up to 200 cm in length.

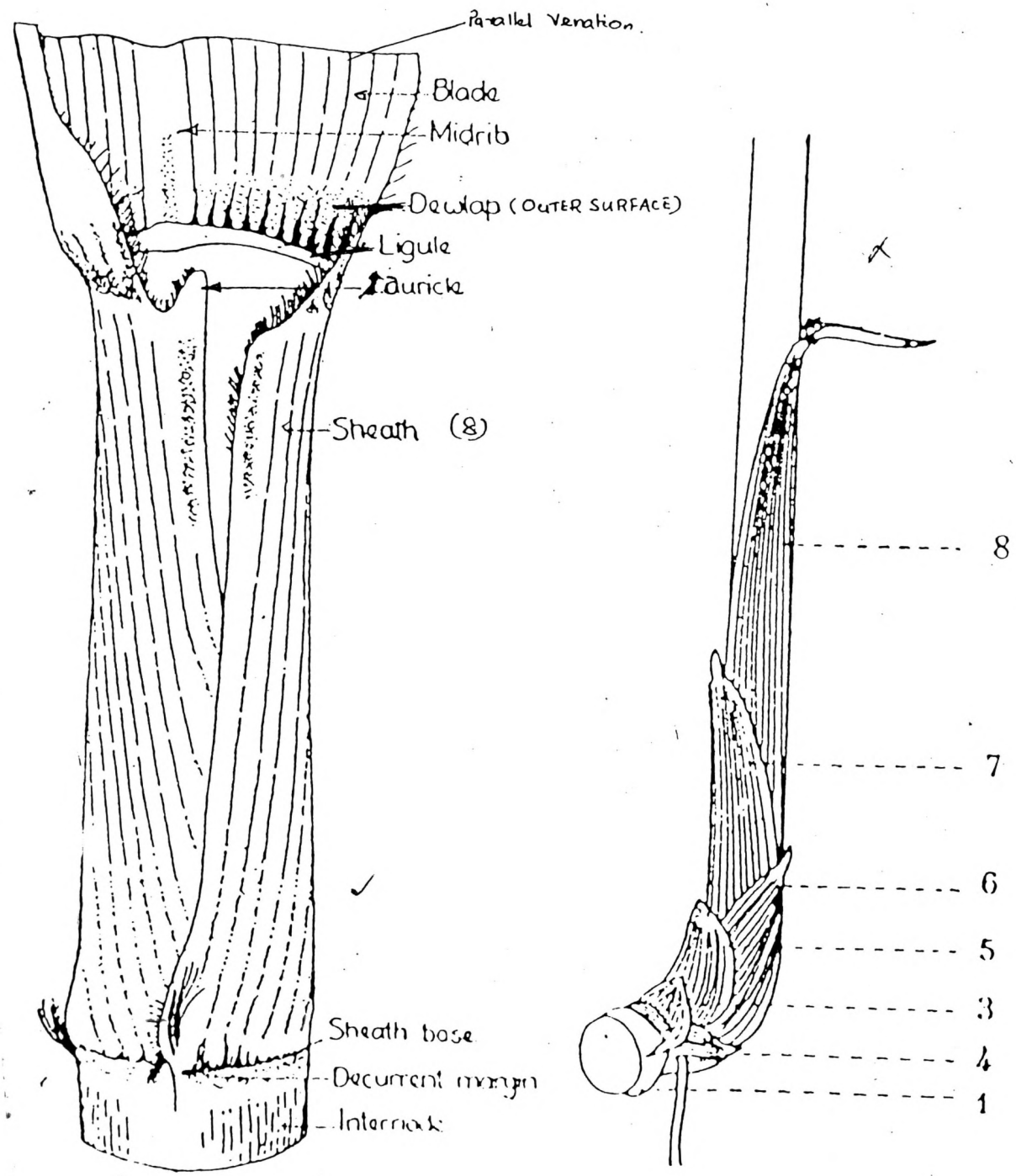


Figure 2.2 Detailed structure of sugar cane leaf

The leaf margin may be coarsely toothed with sharp cutting edges. It has a prominent mid-rib, which is white and concave on the upper surface and green and convex below. Along the mid -rib are motor cells which cause the leaf blades to role under stress, particularly water stress condition.

The leaf sheath and the leaf blade connect at the joint known as the dewlap. A local can be found below the dewlap depending on the varieties.

2.2.3 Root

Sugar cane has a fibrous root system. There are two types of roots, namely, the set and shoot roots (Figure 2.3).

Set or primary roots are the roots originate in the region of the root band and have a limited life span.They are thin and much branched, and provide nutrients to primary shoot till it develops its own root system.

Thick and flashy shoot roots are produced from the basel nodes of the young shoot and branched out into tertiary and numerous fine roots , unlike the set roots. A constant flush of new roots are produced and both old and new ones occur together in a grown up root system. The old root turns brownish-black and its outer layer peel off.

A constant flesh of new roots is produced and both old and new ones occur together in a grown up root system.The old;d root turns brownish - black and its outer layer peal off.

2.3 Cane growth

Sugar cane is a perennial crop which grows in vast climatic conditions. It completes it's life cycle by flowering around 12 to 15 months. Finally, the plants die and new tillers come from the root system of old plant and called ratoon crop. The crop

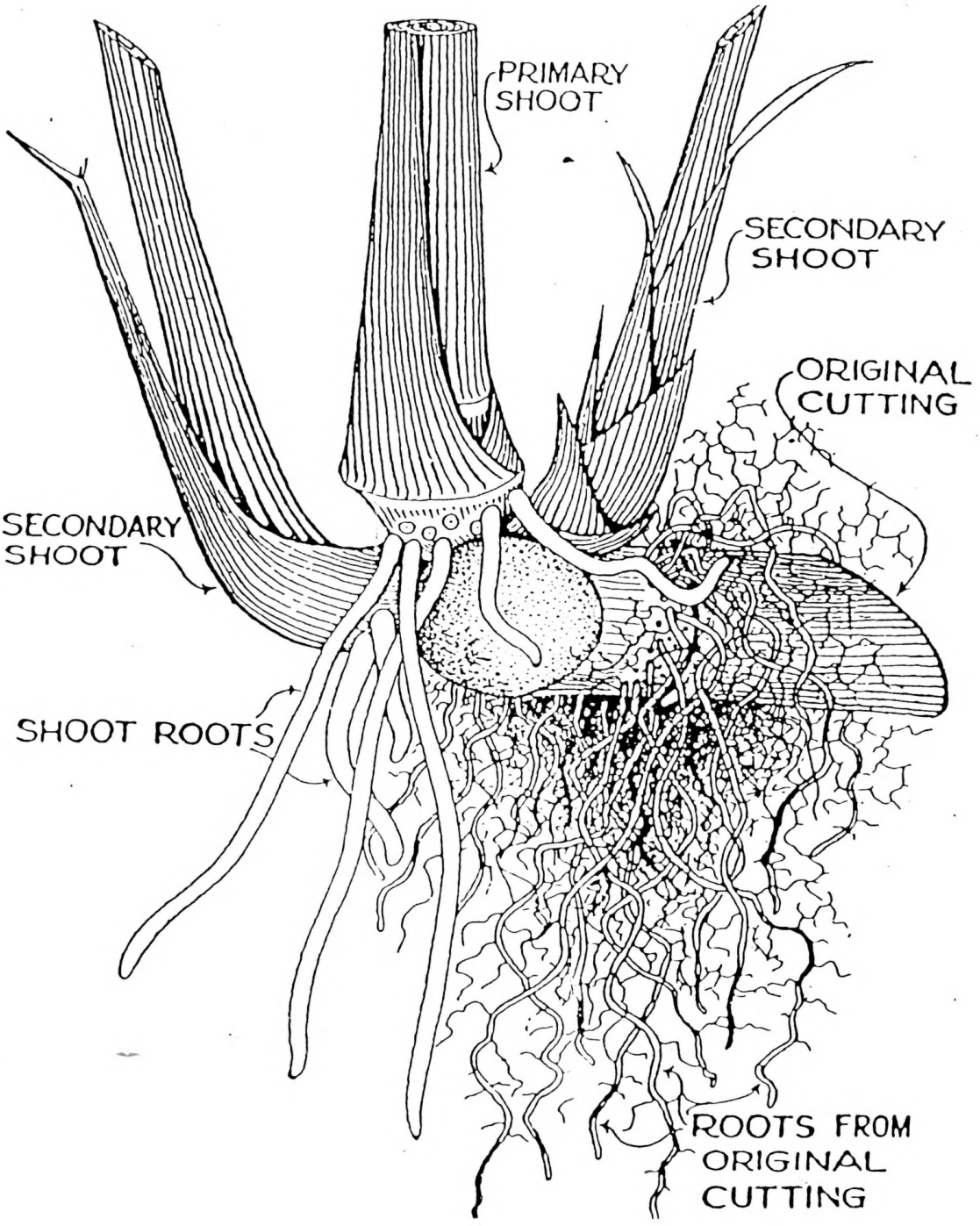


Figure 2.3 Structure of cane root

passes several stages in its life cycle,

a.Germination phase

b.Tillering phase

C.Elongation phase

d.Maturation or Ripening phase

2.3.1 Germination phase

"Well begun is half done",a good germination is obviously very desirable subject to all circumstances being normal. The side buds doesn't germinate well, because the apical dormancy of the plant. Therefore , before planting the stalk remove the apical part of the stalk and are used three bud setts for planting. There buded setts are obtained from 6 to 7 months old cultivation (Chhidda singh ,1983).

The seed setts absorb water and root primordia start to grow or sprout after planting in the field. The bud starts to grow and become a rhizome ,but not a real rhizome and rhizome makes a spike. Finally gives rise to small plant by using the stored food in the stalk and it have 1 to 4 leaves. Good moisture, temperature, soil aeration and seed viability are the most important factors for germination.

2.3.2.Tillering phase

After the germination, the setts roots die and shoot roots are formed. The first appeared shoots are called primary shoot and it form another type of shoot called secondary shoots. Thus the plant density increases and at last called as Clump or Stool. This procedure is taken place continually up to 2 to 3 months after planting(Mettananda,1968).

The size of the clump varies with the availability of light, aeration and nutrients. Sometimes, late tillering can also be seen 6 to 8 month after planting which is not good character in commercial cultivation as thus contain less sucrose amount. These are called Bull or Water shoots.

2.3.3 Cane elongation phase

This called as grand or boom growth of cane plant. Formation of nodes is necessary for the elongation of cane plant and during this period hot air, humid climate and high moisture content are preferred. Thickness and height are also determined in this period. The internode formed during drought, and severe pest and disease attack are shorter.

2.3.4 Maturation or ripening phase

In this phase sucrose produced in the cane stalk, growth of the stalk may retard and at last flowering of cane may takeplace. During this time,conversion of monosaccharide in to sucrose, ceasing of the growth, yellowing of leaves and formation of Arrows or Tassel such physiological and biochemical changers are take place. Cool and low humid atmospheric conditions, nitrogen starvation and low moisture content in the soil are ideal for theses changers (Singlt ,1993).

Flowering can be seen in some varieties and is governed by heredity and environmental factored. Photoperiodism is important for flowering of sugarcane. Flowering is high in areas where the day length is almost constant(12hrs and 7 minutes).

2.4 Factors affecting cane growth

Sugarcane grows most successfully in those areas where the climate is more or less tropical and under warm humid condition. There are four major important climatic conditions affecting in cane growth till it terminated by flowering.

a.Temperature
b.Light intensity
c.Moisture
d.Soil factor

2.4.1 Temperature

In Sri Lanka cane grow well on dry and intermediate zones. The range 25 to 35 ^{0}C is the most preferable temperature for cane cultivation. But during the maturing phase it needs cool night temperature for the accumulation of sucrose in the cell.

2.4.2 Light intensity

Sugarcane is a C_4 plant and needed more light intensity and long day length. Under bright sunlight condition, the stems are thicker, shooter and leaves are border and greener. Day length influences the tillering and flowering and also produces the more dry matter and finally increases the yield of cane(Humbert, 1968)

2.4.3 Moisture content

Cane plant need much water for their growth and need good moisture condition for getting high yield. Normally it needed around 75 to 120 cm annual rain fall for growth, excepts in maturation period.

2.4.4 Soil factor

Sugarcane can be grown in all type of soils successfully from ranging to sandy to clay loam soils. But thrives well on sandy loam soil and saline, alkaline, and acidic soils are not suitable for cultivation.

2.5 Cane maturity and affecting factors

During the maturing period, sucrose accumulation is taken place and normally it undergrow in bottom to top. It is used as a term of maturity. There are few conditions such as moisture, high radiation, age, crop site and low nutrients are affected in cane maturity (Wendt, 1989).

Due to high radiation and low moisture conditions make increases of the soluble solids(BRIX) and reduces of the water in juice. And such as some nutrient like Nitrogen cause the reduction of juice quality and like Phosphate increases the juice quality(BASF journal, 1990).

The location of the cultivation also influences the time of cane maturity,while waterlogging and desert areas make it easy or difficult. Otherwise time taken for maturity varies from 10 to 15 month according to the variety.

The juice composition of the mature cane stalk is varies according to the environmental and variety in slightly. Normal composition ratio in stalk is shown as follows,

Table 2.1 Composition of cane juice

Water	70-75%
Sucrose	8- 16%
Reducing sugar	0.52%
Organic matter other than sugar	0.5-2%
Inorganic compound	0.2-0.6%
Nitrogenous bodies	0.5-1%
Ash	0.3-0.8%
Fibre	10-16%

The juice extracted from cane is an opaque liquid. The colour of the juice various from light grey to dark green. This depends on pigments in the rind of crushed. The constituents of cane juice vary according to the growth stage. Immature cane and over ripening cane contain more organic acids and causes problems during the factory process.

Brix

The brix of a solution is the concentration of solutes, in it. It estimates the total solids dissolve in the cane juice.

$$\text{Brix value} = \left(\frac{\text{Solid}}{\text{Water + Solid}}\right) \times 100$$

The brix % in juice = 15/85 = 17.6 %

Pol

The pol is the concentration or pure sucrose in a solute. It estimates the quantity of sucrose dissolved in the cane juice.

Pol value = How much sucrose

The pol value % in juice = 12/85 = 14 %

Figure 2.4 Samples Taken to Test Pol & Brix values

Figure 2.5 Polarimeter to determine pol value

Purity

The purity represents the percentage of sucrose in total solids of the solution.

$$\text{Purity} = \left(\frac{\text{Pol}}{\text{Brix}} \right) \times 100$$

The juice Purity = 12/15 = 80 %

$$\text{Rendament} = \frac{\text{Sugar Tonnage}}{\text{Cane Tonnage Crush}} \times 100$$

2.6 Post harvest losses

There is also delay between cutting and milling, and between this time several type of deterioration take place.Namely they are categories according to physiological and microbial deterioration.

2.6.1 Physiological deterioration

There is no photosynthesis in cane plant, but number of enzymic activity take place in the stalk and causes losses of sucrose and reduction the cane juice purity.

2.6.2 Microbial activity

After harvesting through the cutting ends and splits,micro organism invade and accelerate the deterioration. This situation make higher in burning cane than in green cane. Mainly micro organism called *Gluconostic mesenteriodes* secrete the enzyme and due to that retard the formation of sucrose and make the poly saccharide called dextran(polymerization).
In green harvested cane losses 6% of sucrose in one day after harvesting, and it is higher in burning cane. It is shown by following figure.

	Full cane.	Topped.
At harvest...	8.55%	10.06%
After three days.	6.24%	7.46%
Losses.....	2.31%	2.59%

(Anonimous)

2.7 Nutrition of sugarcane

To achieve maximum production or yield, the sugar cane crop must be able to obtain enough mineral nutrients from soil to satisfy its requirements. The nutrients are supplied from chemical fertilizers, crop residue & filter mud.

Table 2.2 Nutrient requirement in different growth phases

Growth phase	Period after planting (days)	Nutrients required
Germination period	15 - 30	Nitrogen Phosphorus and Potash
Early growth period	30 - 120	Nitrogen
Active(grand) growth period	120 - 240	Nitrogen
Maturation phase	240 - 360	Nil

Source - Sugar cane growing in Sri Lanka. (by Mattananda, 1990).

The requirement amount of nutrients

* Nitrogen - 100 kg/ha.
* Phosphorus - 20 kg/ha.
* Potassium - 300 kg/ha.

2.7.1 Sources of Nutrients

2.7.1.1 Trash and Tops

The nutrients contained in trash and tops will be returned to the soil, if the trash blanket is left. Most of the Kin the trash is in soluble form and will be leached out of the trash into the soil. N and P are mainly in organic form, and will only return to the soil, when the trash rots down. If the trash is burnt, P and K will return immediately to the soil surface but all the N is lost to the atmosphere.

Table 2.3 Nutrient content in sugar cane

Type of Nutrients		Nutrient content (kg / ha)		
		stalk	Tops and Trash	Roots
Major nutrients				
Nitrogen	N	50	25	20
Phosphorous	P	10	10	5
Potassium	K	125	155	25
Minor nutrients				
Calcium	Ca	16	16	-
Magnesium	Mg	10	15	-
Sulphur	S	-	-	-
Trace elements				
Iron	Fe	10	12	-
Boron	B	-	-	-
Zinc	Zn	3	7	-
Copper	Cu	0.5	0.6	-
Manganese	Mn	0.4	0.5	-
Chlorine	Cl	-	-	-

Source - Sugarcane growing in Sri Lanka.(by Mattananda, 1990).

2.7.1.2 Filter mud

Nutrient content of filter mud varies widely, depending to some extent on its moisture content. Typical values may be about 1% N, 0.6% P and 0.25% K of filter mud and 20 tons/ha is incorporated to the soil during land development or redevelopment.

Most of the N and P are in organic form and will become available slowly as the organic matter breaks down. The K is immediately available for uptake by the crop. Because of difficulties again during transportation. Filter mud will normally be used only in areas relatively close to the factory on those soils which are thought most likely to benefit from the addition if organic matter and nutrients.

2.8 Pests and diseases

2.8.1 Pests

Sugar cane like any other cultivated crop is subjected to the attack by pests resulting in the loss of yield, poor juice quality and low sugar recovery. Majority of the pests of sugar canes are insects. they cause damage to the plants by sucking juice, by making galleries inside shoots consuming stalks and seed materials and spreading disease, etc.

Different species of insects were recorded from different cane growing areas. About 1300 species of insects associated with sugar cane have been listed, from all over the world. But about 55 species of insects were recorded as pests of sugar cane in Sri Lanka with varying degree of importance. Insects pests attacking sugar cane can be classified in relation to the age of plant and to the feeding habits of the pest.

Table 2.4 Pest of sugar cane in Sri Lanka

0-3 Months after planting	3-12 Months after planting	Soon after harvesting
Insects 1. Termites 2. Shoot bearers 3. Trips Mammals 1. Rabbits 2. Porcupines	Insects 1. Termites 2. leaf hoppers 3. Stalk bearers 4. Mealy bugs 5. Scales 6. Roots beetles 7. Leaf eating caterpillars. Nematodes 1. Root parasitic nematodes 2. Free living octo parasitic nematode Mammals 1.Wild boars 2. Wild elephants	Insects 1. Termites 2. Ants

Source - Important Sugar cane pest (Kumarasingha, 1988)

2.8.1.1 Pyrilla perpusilla (Pyrilla leaf hopper)

Pyrilla perpusilla is a major peat of sugarcane. it was recorded as an epidemic at Udawalawe in March 1968. (Rajendra, 1968). The two species of Pyrilla are recognished from Sri Lanka, (P.perpusilla and P.aberrans) Apart from Sri Lanka, P.perpusilla is wide spread in the India subcontinent and is otherwise known from Burma and Thailand.

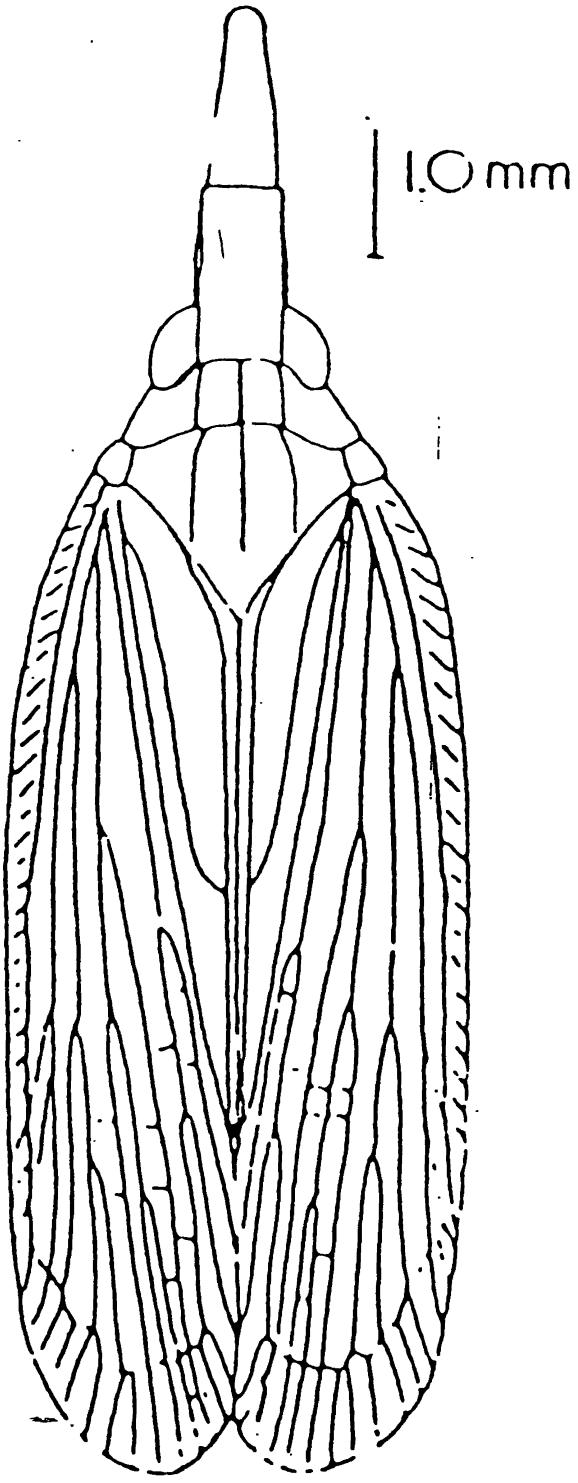


Figure 2.6 Leaf hopper of sugar cane

Damage

Damage is caused mainly by sap removal from the plant by feeding of both nymphs and adults grown crop attacked by leaf hopper result deterioration in the quality of juice. As a result of this sugar recovered in the mill, is adversely affected and quality and yield also suffer. The may influence the juice quality by excessive sap removal from phloem vessels and through reduced photosynthesis consequent to the sooty mould growth, under heavy infestations.

Control

Mainly by natural enemies. There are known egg parasites (Epricany fly). Predacious insects and mycopathogens control the adult leaf hoppers could resort to harvesting.

2.8.1.2 Moth boers

A group of larvae that damage the crop by tunnelling in the interior tissues of young cane shoot(shoot barer) or the internodes (joints) of the cane stalk (stalk barer) , whose adult is a moth.Often these larvae can feed either on shoot or stalk tissues although the degree of preference may depend on the species.

*** Shoot borer (Sesamia inferenes)**

The shoot barer larva tunnels into the young young shoot either of plant or ratoon cane and feeds on soft interior tissues.

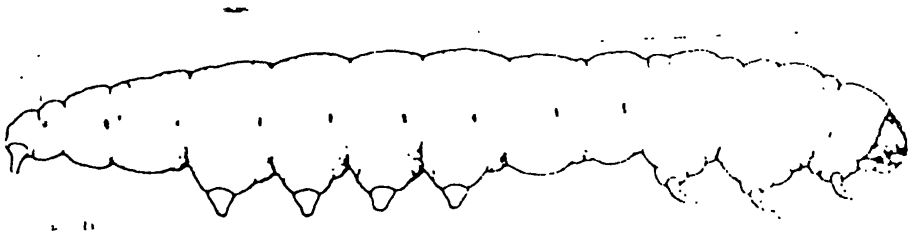


Figure 2.7 Larva of shoot borer

Damage

Entry into the shoot stage of cane takes place by making a tiny hole in the lower portion of the shoot. It eats up the inner tissues of the plant and causes the central whorl of the shoot to dry up and is known as the "dead heart". it is caused by a single larva. Even then the damage level would have to be exceptionally high to justify replanting or supplying solely as a result of shoot barer attack.

* **Stalk borer** (**Chilo sacchariphagus**)

Larvae tunnel into the young expanded internodes and feed on the sucrose storage cells inside. The position of the bored internode in the stalk (top, middle or bottom) and the position of the entrance and the disposal of grass tend to be characteristic of the species involved.

Damage

Damage can be of some economic importance for the following reasons

* The bored internodes showing distorted growth are usually stunted and thin, thus causing losses in cane weight and effecting a weak point on the stalk which is susceptible to breakage and reduces water uptake to later formed internodes.
* Loss of sucrose as a result of direct, larval feeding.
* Loss of sucrose as a result of secondary infection of red rot (fungus). In varieties which are relatively resistant to the disease, this infection may confined to bored internodes only, and it can spread into adjacent, unbarred internodes and even throughout the whole stalk.
* it is suspected that the greater part of sucrose loss occurs as a result of red rot infection. Red rot is not usually serious at P.S.I.

Control

The most successful control measure advocated is the maintenance of weed free fields and field edges. This will basically of weed free fields laying sites. No insecticide application is resorted to because of the danger to the few natural parasites of barer larvae, such as Megaselia spp and Apanteles chilones etc.

2.8.1.3 Mealy bugs (Pink mealy bugs) (Saccharicoccus sacchari)

They are usually found beneath the leaf sheath just above the node. Feeding habit is sucking, through the stylet inserted into the stalk. In the early stages the colony has a white and waxy appearance and in older colonies. The appearance may be greyish, green as a result of various fungi developing on the "honey-dew" excreted by these mealy bugs.

Damage

The pest suck sap from the node, when the infestation is high considerable loss of sugar and death of young shoots may occur. The damage on the cane is not-likely to be any economic importance. Although heavy infestations may produce large quantities of waxy substances, which may interfere with clarification at the factory.

Control

* The effective control achieved are by cultural control,by using pest free seed cane removal of trash and stable preventing carry over of the pest into the new field.
* Chemical control method is not economical, but use of B.H.C, Aldrin, Dieldrin and Folidol.
* Biological control is also done Carpophilus marginellus mots and Gitonaper spp are used as parasites.

2.8.1.4 Termites

They are present in the soil of all warmer areas of the world, where sugar cane is cultivated. Their number vary greatly from place to place.

Damage

There are three periods when most termite damage occurs

* Soon after planting, the termites bore into the ends of the setts and remove the soft inner tissues, and growth is stopped and the sett is lost.
* When the canes begin to ripen and growth cease, termites are then able to penetrate the outer layers of the stalk and tunnel about inside.
* After cutting, the stools are vulnerable, after harvest as the cut ends of the stubble allow entrance to termites and the subsequent development of ratoons is hampered.

Control

Removal of tree stumps and roots from soil, in the case of heavy infestations insecticides like aldrin or dieldrin could be poured down the mounds (Kumarasingha 1988).

2.8.2 Diseases

Sugar cane crop is attached by several diseases caused by several organisms such as Bacteria,Virus,Fungi,Micor plasma etc. The symptoms appear on leaf, stalks, root, flowers and seeds. In Sri Lanka Smut,Grassy shoot disease,Ratoon stunting diseases, Mosaic,Pokkabone and Leafscold are the major diseases.

2.8.2.1 Smut

This disease is caused by a fungus called *Ustilago scitamina.* The symptoms of this is produce a wipe like structure and it is 1m long and 0.5 mm in diameter, contain 5000 millions of spores. Therefore few infected plants may infect the entire field of all stages of plants. The wipe is generally produce by the primary

infection of seed cane,when age is 3 -4 months. But secondary infection also can be seen in the plants.

Diseases plants may appear several abnormalities both in vegetative and reproductive parts. The conspicuous symptom of smut are reduce in the size of plant, produce more tillers than healthy one, reduction of the size and grith of internodes with concomitant deepening of the bud groove can be observed. The infection of the crop is depend on primary or secondary infection, ratoon crop, time of growth etc.

Control measures

1.Planting of healthy seed cane
2.The infected plants are removed from the field
3.Resistant varieties are planted in the field
4.The treated seed cane which is subject to hot water treatment or chemicals is used for nurseries
5.Crop rotation is practised in commercial fields
6.Growing companion with some crop (eg.Cajanus cajan)

2.8.2.2 Grassy shoot disease

This disease is popular in Sri Lanka,Burma,Sudan,India etc and caused by mycoplasam like organism. Diseases characterises are produce in numerous tillers with narrow leaves or without albinism. And total plant may become white colour. Hardly one or two thin millable cane were produced in a clump and don't produce a inflorescence or arrow. The root system of affected plants are considerably reduced and don't grow the ratoon crop also.

Control measures-

1.Healthy seed cane are used in nurseries.
2.The seed cane are subjected to the hot water treatment.
3.The diseased plants are subjected to destroyed.
4.Resistant varieties are planted in the nurseries.

2.8.2.3 Pokkah boeng

This is observed in Java in early and caused due to fungus called *Fusarium moniliform.* It is found in Pelwatta plantation also. The symptoms of this disease are development of chlorotic conditions towards the base of young leaves, distortion of younger leaves and in some cases distortion of stalks etc. Finally,hole plant were died.

Control measures

1.Seed cane are subjected to the hot water treatment.
2.Uprooting and burning the diseased stalk.

2.8.2.4 Leaf Scald

Caused due to bacteria called *Bacterium albanians.* The symptoms are elongated narrow, white to yellowish strips are found on leaf blade and reddish brown spots may be found on chlorotic tissues. As the lesion mature, the loss their sharpness of outline of the affected leaves.The affected stalks produce large number of shoots and split the stalks in node area.

Control measures

Resistant varieties are used when planting.
hot water treatment is also practised when planting in nurseries.
Healthy cane are planted in nurseries or in fields.

2.8.2.5 Ratoon stunting disease

This is caused due to bacteria and losses are more severe in under stress conditions. The yield of the crop may reduce up to 20% to 40% and decline the successive ratoon crop.The diseased ratoon became stunted and give un appearance in field. When spiting the stalk, reddish brown spots can be seen. This is spreader by the implements in field.

Control

1.The resistant varieties are grown in the field.
2.Seed cane are subjected to the hot water treatment.
3.Implement to be sterilized before using.

2.8.2.6 Mosaic

This is a virus disease and symptoms may appear on younger leaves than older leaves. Generally yellowish or chlorotic strips appear on green portion or the leaves. Due to this destruction of chlorophyll in foliage is occurred.Transition of virus is done by mechanically or insects.

Control measures-

1.The resistant varieties are used to control the disease.

CHAPTER III

OBSERVATION AND DISCUSSIONS

3.1 Observation on Sugar cane Cultivation and Crop Management.

3.1.1 Land preparation

If the soil is very hard and dry and the plough cannot penetrate, then ripping is done with a hydraulically controlled ripper. Ripping nearly opens up the soil. Ripper of course is very similar to the rooter except for fact that the angle of the shoe is different.In case of ripper the angle of the shoe enables the ripper shanks to penetrate, whereas in the rooter the shoe is covered, helping the buried roots and other obstruction to get rolled up and out of the ground.
If there is sufficient soil moisture, that land has first got to be ploughed. For a heavy plough to penetrate to a depth of 15" to 18". Ploughing of the land is generally a rule and this ploughing is followed up with a cross ploughing. Ploughing is preferable to ripping as ploughing brings about a complete inversion of the soil. Thereby burring all the weeds. Ploughing is done with the use of Majestic Plough or Rome ploughs, where the discs are of 32" diameter.

When ploughing or ripping is done, there will be large clods of soil, which have to be broken up. This is done by harrowing is followed up with a cross-harrowing. In the first land plan, all high spots all smoothed local low areas are eliminated to prevent surface water accumulation of the natural land slop. In the second land plan, land plan is done along direction the furrows.

**** Preparation of furrows.**

Furrowing the land at 1.5 metre spacing with equal width of furrow and ridge. the furrows must be straight and

evenly spaced. They should be 25 cm deep below the field surface and have an adequate planting tilth, whenever possible the furrows should be aligned so that they are not in excess of 1 % slope and meet field head lands and roots at 90^0. Short rows should be avoided whenever possible. Furrowing could be done either by the use of a cutter planter or by a tractors.

3.1.2 Production of seed cane in P.S.I(Pelwatte Sugar Industry)

At Pelwatte the main sources of seed cane are the seed cane nurseries and areas. The system , primary nursery and secondary nursery are included.

3.1.2.1 Primary nursery

All cane grown in the primary nursery is from seed which has been treated against ratoon stunting disease. This is done by treating the seed in a tank of water heated to 50.5^0C for a period of 2 hours. The tank is situated at Yalabowa and the temperature is maintained. At Yalabowa all the first plantings are made from carefully screened seed stock.

3.1.2.2 Secondary nursery

Selected cane from the primary nursery is used for planting in the secondary nursery, all of which are controlled by Nucleus Estate. There are three secondary nurseries situated within the P.S.I Nucleus Estate and one at Yalabowa.These are

Section 1

Kuda Oya - 34 hectares (hec's)
Kukurampola - 15 hec's plus 6 hec's planned extension.

Section 2

Menik Ganga - 30 hec's plus 6 hec's planned extension.

Section 3

Diyakiritha - 30 hec's and
Yalabowa - 30 hec's plus 10 hec's planned extension.

Seed production within the secondary nursery system is continually checked,inspected and irrigation is carried out on a continuous cycle of 75 mm every ten days.

3.1.3 Land preparation for the nursery.

It is of high quality to ensure that the old crop residues are totally destroyed. This may be done by deep ripping followed by two or more ploughing and disc harrowing.(Ian Mointash, 1988).

3.1.3.1 Rouging

After the land preparation, rigid inspections are made to ensure that no volunteer stools have again germinated from the old crop. The practice must continue throughout the germination period starting for just after the final preparation first months of growth of the new crop.

3.1.3.2 Planting in the nursery

It is regulated to provide suitable seed at the required times for the field planting.

Table 3.1 The period of planting in nursery

Nursery	Season	Time
Primary	Maha	in July
	Yala	in February
Secondary	Maha	February - March
	Yala	September

Source : Field operation manual (Mointosh , 1988).

3.1.3.3 Fertiliser application

It is as for Maha commercial planting, except that a final top dressing of Urea at the rate of 50 kgs. Urea/ha may be applied to seed canes about 6 weeks before the planned seed cane harvest. In the soil with high N content, the cane germinates better than poor n conditions. The top dressing of 50 kg of Urea per hectare is applied ratoon cane in the nurseries 6 weeks before harvest.

3.1.3.4 Irrigation

In considering seed cane production irrigation is essential to provide the conditions necessary for the production of succulent young cane for harvest at six to nine months of age, which is ready at the right time for planting.

In P.S.I sprinkler method of irrigation is practised, and water is applied for 10 hours continuously. It is called 10 hours cycle irrigation. At that time, it gives 50 mm of rainfall.

But 5.0 mm of water is lost from the cane field per day, which depends climatic conditions.

During the early stages of growth, it is not necessary to irrigate in 10 hours cycle. It can be reduced up to 6 hours

cycle and thereby about 25mm of rainfall is obtained.

Figure 3.1 Irrigating the nursery

3.1.3.5 Disease control

The general use of all regular preventive practices such as the sterilising of cane knives and the fungicidal dipping of can sets are practised. 1 % of formaldehyde is used for the sterilization.(100 ml of formaldehyde with 10 litres of water).

In the early stage of growth by applying hot water, at 50.5^{0}C for 2 hours. The disease like smut and grass short disease (G.S.D) can be prevented, while with increasing temperature up to 52^{0}C. All other diseases can be prevented.

Cane is heated to 52^{0}C for 2 hours and again hot water treatment is practised for 2 hours, then cold. In this case all disease and the causal agent can be controlled. But the germination ability is 40%, whereas 60% in the heat treatment of 50.5^{0}c.

3.1.3.6 Planting in the plantation

The density of planting sett is higher than that of commercial field, because double line continuous method is practised in the nursery beds,whereas single and 50 % over lapping methods are practised in the commercial field. The space between two rows may vary from 1.3 m to 1.5 m About 7 - 12 tons of seed cane is adequate for 1 hectare of land surface.

3.1.3.7 Inspections

The regular inspection is necessary to obtain healthy and vigorous young plants.

3.1.3.8 Harvesting and transporting

The harvesting is done 6 - 8 months after planting and cane is not used as seed cane in (10 - 12) months of age. Cane

knife must be sterilized using a solution of formaldehyde (mixed at the rate of 100 ml in 10 litres of water) when harvesting. Cane cut should be topped, left un trashed and placed in piles on the field edge for ease of loading. Cane is not trashed so as to give protection to the tender eye buds in loading and during transport. Seed is transported carefully over the minimum practical distance and unloaded by the best practical means. Seeds, which are unable to use immediately is best left either un trashed or trashed, chopped and dipped and than covered again with the old trash ti give protection from drying.

3.1.4 Planting

3.1.4.1 Planting material

Either seeds or pieces of stem can be used for the propagation of sugar cane. But the seeds are very small in size and on the other hand most of the varieties do not make flowering. And seed weight is also very less. Therefore most probably the sugar cane plant is reproduced through the buds on the stalk.

Uniform plants cannot be obtained by planting whole cane, therefore the piece of stalks which contain 2 - 3 buds are planted as cutting or setts.

The buds on the upper portion of the mature stalk, which contain vegetative cells germinate better than those on the lower. Therefore the half top portion of the stalk could be used as seed cane, if the stalks are old.

Seed cane

It is importance to obtain the seed cane from sources which had been started from specially selected cane of the pure variety and healthy and free from pest and disease attacks for the establishment of nursery.

the establishment of nursery.

P.S.I practices with many varieties which are recommended by S.R.I Udawalawe and able to provide a good seed cane to its own nucleus and even for setters and out growers too.

Considering the size of buds, the setts having small size buds are better for planting, because the small size buds are still in a vegetative phase. When the selection of a good seed cane, the internodes must be long,otherwise the filtering would be very high resulting high density of plants and eventually there is a competition for light, nutrients and root growth.

3.1.4.2 When to plant.

If it is rained cultivation, the annual rainfall should be more than 1500 mm. The distribution of rain fall should not be throughout the year but alternative one.In P.S.I, the rainfall is 1400 mm and 70 %during Maha season and 20 % during Yala and 10 % intermediate rainfall. It is called moderating rainfall. There are two seasons, short season and long season with coincide

February - April and September to December. The planting must be done earlier as possible depending on soil types, availability of moisture etc.

3.1.4.3 Where to plant.

The common method under all conditions (rainfall, irrigated and drainage) is to plant in the ridge and furrow system. In shallow soil, the furrow should be 10-15 cm deep and 22 - 30 cm in case of deeper soils. A furrow with higher gradient should be avoided as it will promote soil erosion. In water logged conditions the furrow should be formed making use of the steepest slope available and planting should be done on ridges.

3.1.4.4 Seed rate

The normal amount of 3 budded setts required per /ha for different furrow spacing.

Table 3.2 Seed rate in the planting

Row spacing	No. of setts required per ha
135 cm	24,000
120 cm	27,000
105 cm	31,000
90 cm	36,000

Source - Sugar cane growing in Sri Lanka. (Mettananda,1990).

3.1.4.5 Varieties used by P.S.I.

* Co - 775
* M 438/59
* K - 7130
* SL 8306

About 65% of land is planted with Co - 775, whereas 35% of land is planted with other varieties.

3.1.4.6 Planting operations

Preparation of seeds should be cut at or below ground level and just below the growing point at the top. They have the trash removed by hand and chopped into cane setts or seed pieces.

Using a straight cane knife setts will be 40 - 50 cm long and will contain three or more eye buds. The setts are quickly dipped in a solution of **BENLATE** (100g of benlate in 75 l of water). The ends of the setts require thorough wetting and there is no need for a lengthy immersion to control the pest and disease. Totally requirement of benlate per hectare is 200 g.

3.1.4.7 preparation of furrows

Furrows made in the morning (15 cm deep, 1.5 apart) should be planted the same day, when weather conditions are dry.

Fertilisers (Urea & triple super phosphate) are applied directly to the bottom of the newly opened furrow.

3.1.5 Maintenance in sugar cane cultivation

3.1.5.1 Fertiliser application

* Basal dressing

Urea and triple super phosphate (TSP) are used in basal application.

For Maha season - 90 kg/ha Urea
- 180 kg/ha TSP

For Yala season - 180 kg/ha Urea
- 180 kg/ha TSP

(all TSP is applied at planting time).

* Top dressing

Generally 90 kg of Urea is applied for one hectare of cultivation as top dressing, only Maha season 6 weeks after planting, because of an anticipated lack of moisture at 6^{th} week of Yala season no top dressing as practised. The placement of Urea is directed again along the bottom of the still open furrow and around the young growing cane shoots.

3.1.5.2 Gapping

Gapping is the term used for filling the empty spaces left in the rows of the new cane crop by poor germination, pest attack etc.In general gaps of 1m or more will be replanted. Generally Maha planting will carry sufficient moisture for

gapping to be completed. For Yala planting there will be less moisture in the later stages so the 5th week is taken as a general guide. Gapping can take place in Yala plants at the beginning of the Yala rains.

Figure 3.2 Evenly grown sugar cane plants

3.1.5.3 Moulding up or Earthling up

*** Mechanical moulding**

Moulding up is generally carried out by a machine mounted disc implement. The discs run along and between the cane rows and throw soil from the inter row area to the cane row. The

time of the operation is important, because early will inhibit tailoring as well as too late may cause damage and break cane stalks. Nine weeks are a general time guide.

*** Manual moulding**

Moulding operations will generally be done by machine.
In those areas where a machine cannot be used the operation will be carried out by using a mammoty.

3.1.6 Weed control

3.1.6.1 Manual weeding

Table 3.3 Weed control in the plantation

Cane	Time of weeding	Duration (after planting)	Area (in percentage)
Plant cane	First	16 weeks	100 %
	Second	20 weeks	70 %
	Third	24 weeks	30 %
Ratoon cane	First	12 weeks	100 %
	Second	16 weeks	100 %
	Third	20 weeks	70 %
	Final	24 weeks	30 %

Source - Land clearing and Field preparation (By Hughan, 1982).

3.1.6.2 Mechanical weeding

In mechanical weeding implements of various types are drawn behind a tractor. Tined cultivators stir up the soil surface, digging up or loosening the roots of shallow rooted weeds. Disc cultivators move the soil and bury small weeds.

3.1.6.3 Chemical weeding

A wide range of different herbicides (Systemic, contact, and residual or soil acting) has been developed and they are effective against various types of weeds applied at various stages in crop and weed growth.

3.1.7 Harvesting and Transporting

Cane should be harvested only if it is well ripened. To facilitate ripening which is generally accelerated by cool dry weather, irrigation water is withdrawn about a fortnight, before ripening.

Cane maturity can be tested with the help of a hand refractor metre which can measure the percentage of dissolved solids (total sugar plus impurities) in the juice. The percentage of total solids or degree of brix, as it is called can give a fair idea of the quality of the crop.

Harvesting operation may be performed either by hand or machine. To be ensured that the cane harvested and delivered to the factory is clean, free from immature tops, trash, soil and other foreign matter, the trash is sometimes burnt before harvesting.

After harvesting, the loading and transport to the factory should be well organized to avoid delays and consequent deterioration in sugar content. In many sugar cane growing areas loading and transport are mechanized. Loading is done by CAMECO loaders which pick up the bundles of stacked cane and load these into the cane trailers, The trailers carry an average of 8 tonnes per load.

3.2 Observation on Post Harvesting of Sugar cane and Manufacture of Sugar

3.2.1 Post harvest of sugar cane

The quality of cane juice is affected by several factors. They are environment, cultural and mechanical factors. The loss in quality of juice is higher in the field cane than that of harvested without firing . 10% out of total quality of juice is lost during fired harvesting. The temperature of environment also causes severe effect on juice of cane. About 8-10 % of juice is lost in a period of after harvesting. There is a formation of cracks on stems when the cane is fired. Thereby , certain kind of harmful micro organisms enter through this cracks and cause adverse affect on juice of cane. Anyhow, the cane should not be allowed to lay in the field more than 48 hours after harvesting. there is possibility to mechanical injuries and wounds on the stem during loading and transporting.

3.2.2 Sugar Manufacturing Technique

In the evolution of the sugar manufacture, its processing technique has improved constantly with the science and technology of the world sugar industries and it has now developed into as intermediate technique between the traditional gaur making and the modern sugar processing techniques.

In the Pelwatte Sugar Industry, there are six major steps for the sugar making. such as follow ;

* Cane feeding.
* Milling or Extraction of juice from cane.
* Purification.
* Evaporation of purified juice.
* Crystallization of syrup.
* Drying and bagging.

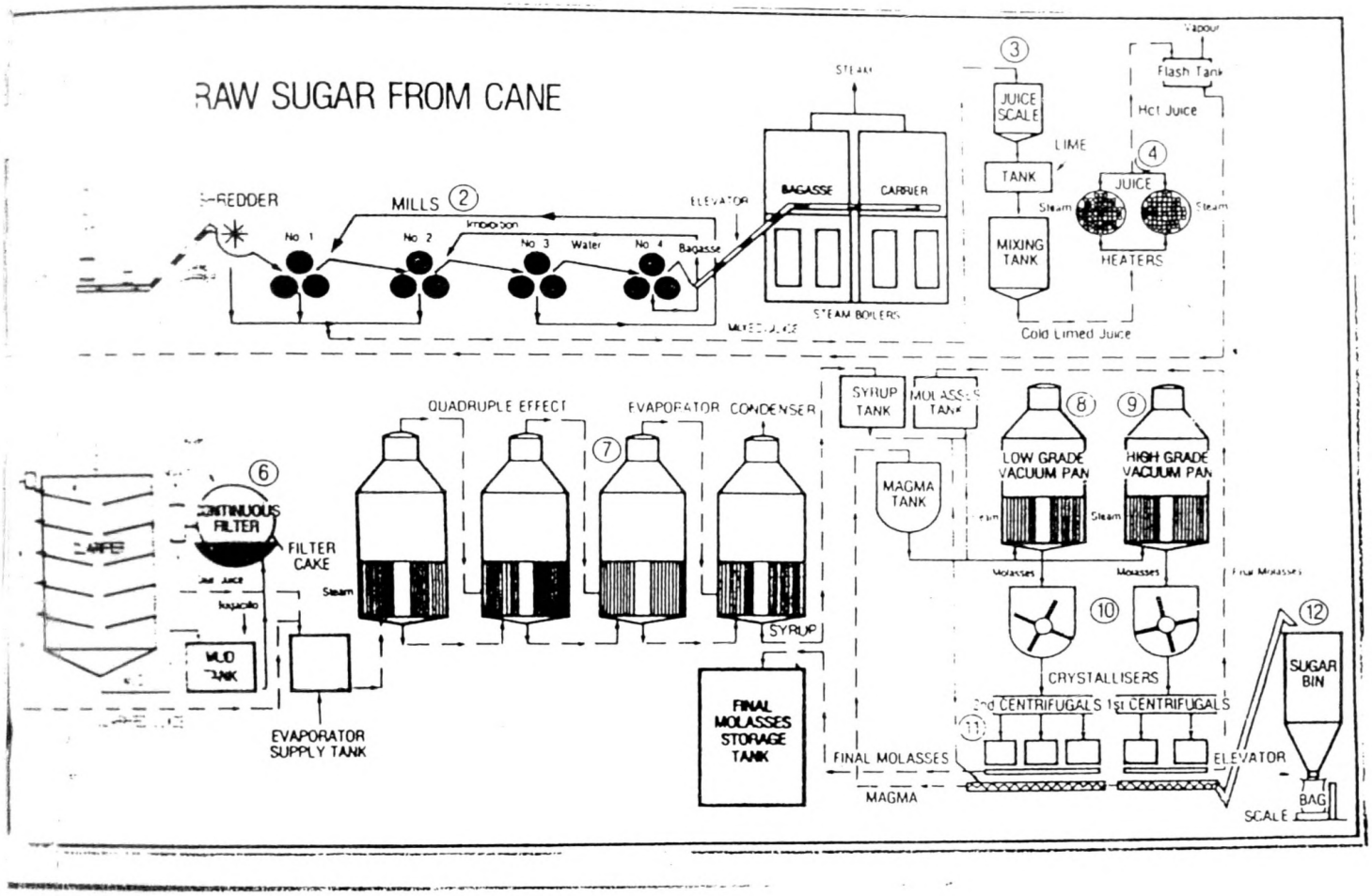


Figure 3.3 Processing of Raw Sugar from cane

3.2.2.1 Cane feeding

Cane feeding is the first step of the sugar manufacturing. The sugar cane is loaded into steal open containers (Capacity 8 - 10 tonnes) by the use of machines known as " kemico " cane loaders. These canes are directed to the cane feeder table. it is a platform. Which carries, the cane forward until it falls into the cane carrier. The kicker has been fixed with feeder

table to make evenness of the cane reduce the difficulties in the cutting section. Approximately 150 -175 tonnes of cane is feted into the feeder table per hours.

Then the cane passes through two set of cane knives to the shredder and pass through rotating knives fixed to shafts a cross the carries. So that all cane entering must pass underneath the blades and will be cut into small chips.

Figure 3.4 Cane feeding table

Then these cut particles will be cut into more small particles by the second knife. After that these small particles are passed through the heavy duty shredder on its way to the first mill.

3.2.2.2 Milling or Extraction of juice from cane

The final preparation of the cane, enables grater through put of the mill and make juice extraction process of mill rollers, which lie horizontally.

In the P.S.C, there are four sets of mill and each mill contains **Top, Delivery and Feed rollers**, the shells grooved 45 degrees at 50 mm pitch to increase the surface of the rollers. The cane is then crushed twice, first is passed between the top roller and feed roller, then it is passed between the top roller and delivery roller. Then it flows between the feed roller and delivery roller.

The top roller is loaded to approximately 500 tonnes and can float to 32 mm. This applies as even pressure to the cane blanket and crushed out the juice. The cane is crushed twice in each mill and the ratio of opening is about 2 : 1. Thus at P.S.C the cane is crushed eight times in all.

After the removal of juice, the cane fibre acts like a sponge, which is called **Bagasse.** Normally the 1^{st} mill bagasse passes through the 2^{nd} mill and the 2^{nd} mill bagasse passes through the 3^{rd} mill. When the bagasse comes out of the 3^{rd} mill, imbibition water is sprayed on it, in order to extract maximum juice. Then bagasse, which is added water enters to the 4^{th} mill.

The extracted juice from the 4^{th} mill is added before the 3^{rd} mill and the 3^{rd} mill juice is added before the 2^{nd} mill. Therefore the juice is concentrated at the first 2 mills.

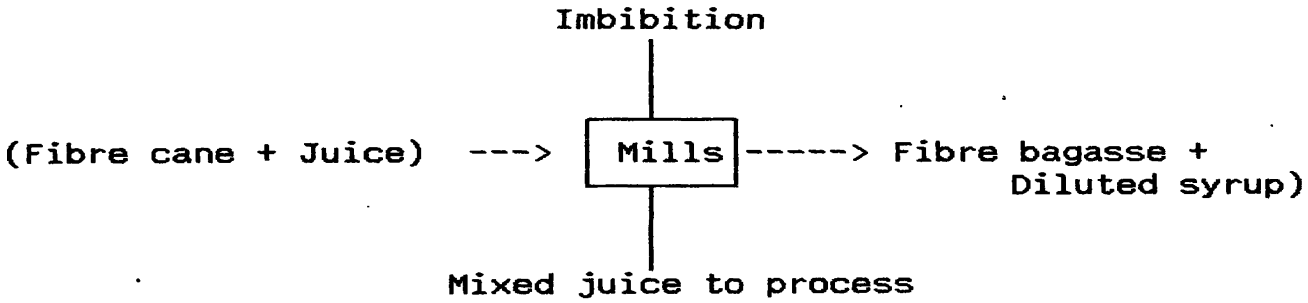
The juice from the 1^{st} and 2^{nd} mill is collected and passed over a screen to remove bagasse particles, before flowing to the mixed juice tank. This tanks is filled with bottles and sand extractor to remove sand before the juice is pumped into the process house. Anyhow, 94 % of juice is extracted and 6 % of the juice is lost with bagasse.

y

The bagasse is used as fuel for the boiler t^O made steam, which provide generates power (electricity) for processing.

About 560 tonnes of bagasse is produced per day and 1000 tonnes of bagasse is saved in a week. The boiling temperature is 380^{0}C and the heating surface is 1340 m^2.

As bagasse is made up of approximately 50 % water 3% sugar and 47 % fibre (solids) it can be seen easily that the more the bagasse, the greater amount of sugar is burnt in the boiler instead of going in the bag.



$$\text{Mill Extraction} = \frac{\text{Tonnes Sucrose (Pol) in mixed juice}}{\text{Tonnes Sucrose (Pol) in cane}}$$

Tonne Bagasse = Tonnes cane + Tonnes Imbibition - Tonnes mixed juice

3.2.2.3 Purification

The mixed juice is pumped to the process house, and weighed in the juice scale automatically. The weighed of this juice is possible to fine out how much sugar has been produced. The weighed mixed juice is sent to the juice clarification section to remove impurities as early as possible in processing.

In the clarification stage after heating the juice to about 70^{0}C - 75^{0}C in the first stage juice heater, the juice is limited to

matters are leaved as gas or steam.

Then, the juice moves into the sulphuration tank to contaminate with So_2 gas. The sulphated juice is limed ($Ca(OH)_2$) again and pumped into the clarifier via secondary heaters. The clarifier has 4 compartments which are like 4 setting tanks, placed on top of each other. The liquid is allowed to in settle for certain time. The clear juice is called as **clarified Juice**. Then clean juice is sent to the evaporator.

The impurities settle at the evaporator from a mud which is very gently scraped to the centre and removed of the filter station. Clarification helps to extract a large quantity of juice and this juice contains sucrose.

The mud that settle at the bottom of the clarifier now contains part of the impurities which we don't want in the sugar. A small amount of juice is left with mud. Rotary vacuum filters are used to separate juice from mud. this mud is called **Filter cake**. This filter cake is taken out by conveyers from the factory as and used as fertilizer.

3.2.2.4 Evaporation of purified juice

The clarified juice goes to the boiling process for concentration. This is carried out by means of open pan evaporators known as juice bells.

The evaporators are large vessels which are inter connected with vapour lines. In the P.S.C, there are available 5 vessels evaporators. By the time the clarified juice has left the final vessel. It has lost a great deal of water and consists of at east 65 % dissolved solids which is called **Syrup.**

The syrup, then passes to the vacuum pans. A pan is a evaporating vessel for boiling 4 syrup to form a high viscosity substances

called **Masscecute,** which is a mixture of crystal and molasses. This is done by evaporating of water from syrup, leaving behind the sugar material under vacuum to avoid caramelizing.

Three boiling system have been introduced in Pelwatte Sugar Industries in order to get a high sugar recovery and good quality sugar.

3.2.2.5 Crystallization of syrup

From the vacuum pan the masscecute doesn't go directly to the centrifugal separates. It first flows to a receiver or crystallizer where the crystallization occurs and contain to grows as it cools by taking up sucrose from the mother liquor.

This liquor is then fed from there to the centrifugal to separate sugar crystals from the mother liquor (called molasses). The molasses pumped to the storage tank as final molasses (In 3rd stage)

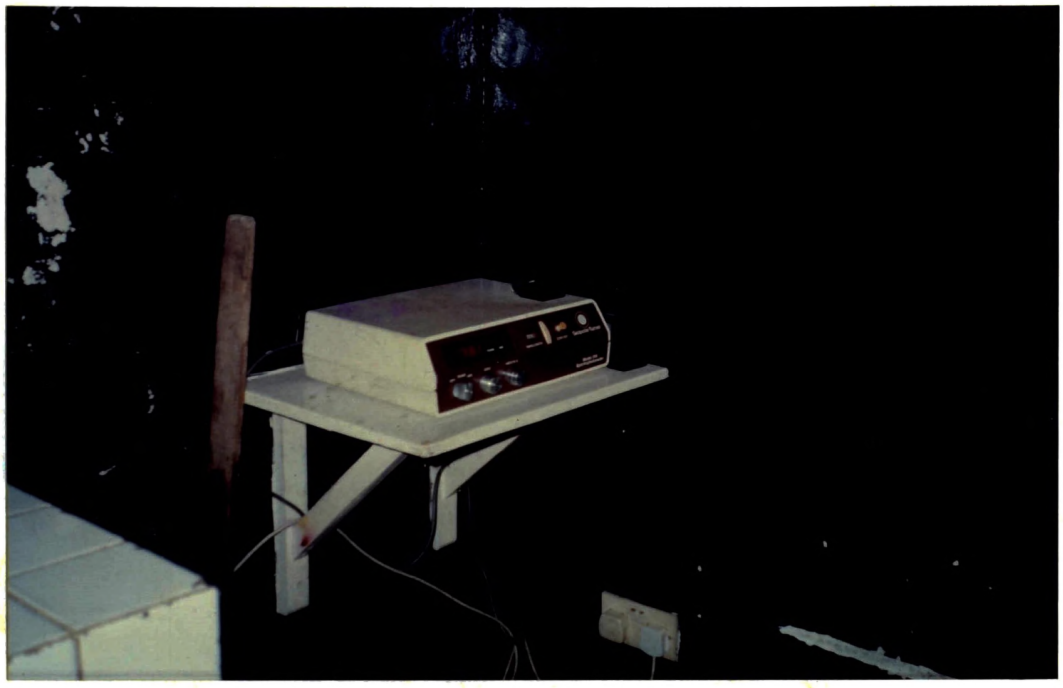


Figure 3.5 Colorimeter to determine the colour of sugar

3.2.2.6 Drying and Bagging

Finally sugar is pumped on the horizontal type rotary dryer. It is very essential to maintain sugar moisture (0.06 % - 0.07%) in order to produces good quality sugar.

Then the dried sugar is in produced into large containers (sugar bins) which are connected to the bagging machine.

The bagging machine has been designed to weigh exactly 50 kg of sugar in each bag. After weighing sugar bags are stitched by machine, and sent to the warehouse, to be despatched as necessary.

3.2.2.7 The product capacity of factory at P.S.I

* Highest tonnage of cane milled per day 4142 MT(24.08.93)
* Highest tonnage of cane milled per week 23476 MT
* Weekly sugar made an estimated 2121.13 MT
* Highest major bagasse per week 2107.05 MT
* High number of pans depend per day 34 numbers including 'A' pans on 24.08.93.
* Highest amount sugar bagged per day 391.55 MT (25.08.93)

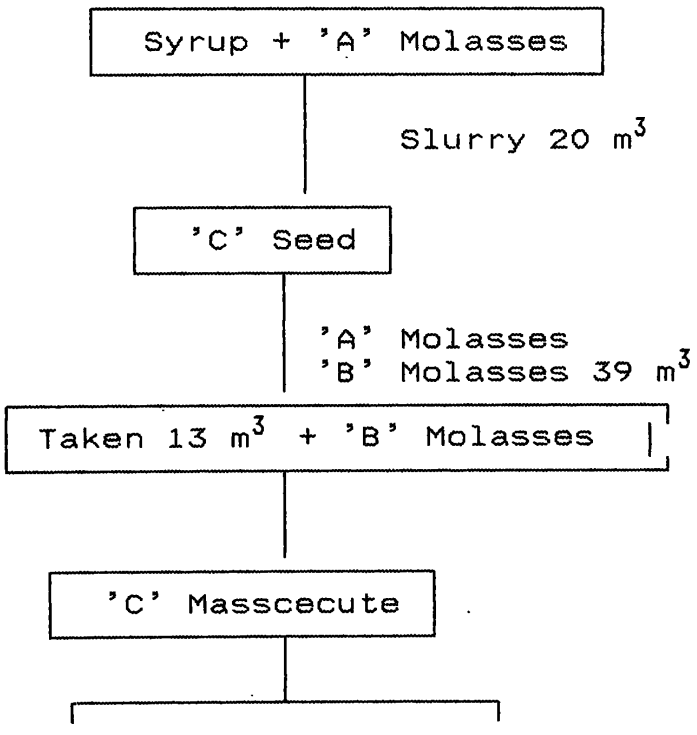
Figure 3.6 Factory of P.S.I.

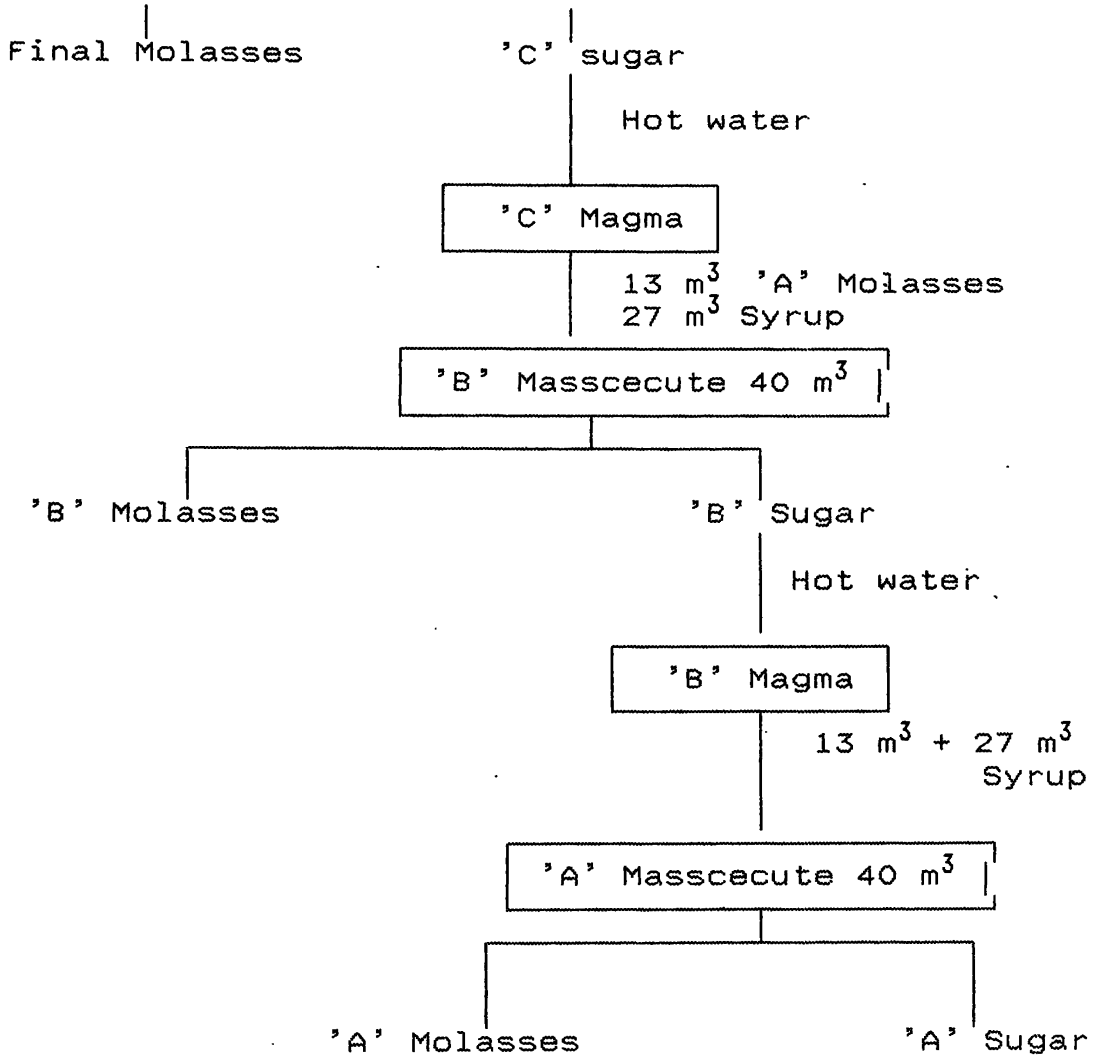
3.2.2.8 The Flow Diagram Of Pan Process

The 'C' seed is prepared by adding syrup 'A' molasses and 20 m^3 volume of slurry. Then 'A' molasses and 'B' molasses are added into the 'C' seed. Then the 'C' masscecute is prepared by using 27 m^3 volume of 'B' molasses and 13 m^3 volume of 'C' seed. The 'C' masscecute is separated into final molasses and 'C' sugar by centrifugal processing. Then the hot water is added with 'C' sugar and melted to form 'C' magma. After that 13 m^3 volume of 'C' magma and 27 m^3 volume of 'A' molasses are mixed together to make 40 m^3 volume of 'B' masscecute and this masscecute is separated into 'B' molasses and 'B' sugar. Then the hot water is added into 'B' sugar and melted to make 'B' magma.

After that, 13 m^3 volume of 'B' magma and 27 m^3 volume of syrup is mixed together to make 'A' masscecute. Finally this 'A' masscecute is separated into 'A' molasses and 'A' sugar. A sugar is marketed as commercial sugar for the consumers.
The flow diagram of pan process is as follow :- (Next page)

Figure 3.7 THE FLOW DIAGRAM OF PAN PROCESS





3.3 Quality Management

3.3.1 The effect of Dextran on sugar products

3.3.1.1 The meaning of dextran

There are several factors, that affect the juice and sugar. Especially harvested cane should be transported to the sugar manufacture site immediately. After the harvesting; the longer the harvested cane left in the field, less the sugar quality.

Most probably, the cane fields are burnt, before harvesting to make easy for the harvesting activities. Normally there is a wax layer around the stem of the cane. But this coat

is removed by the burning activities. Therefore, many cracks are for ed on the stem of the sugar cane,due to the removal of this wax layer. This also may encase micro-organisms to enter through this cracks as through both cut ends.

For example, bacteria called lueconostoc mesenteriods. enter into the stem of the cane and cause its spoilage activities can reduce the quality of cane juice.

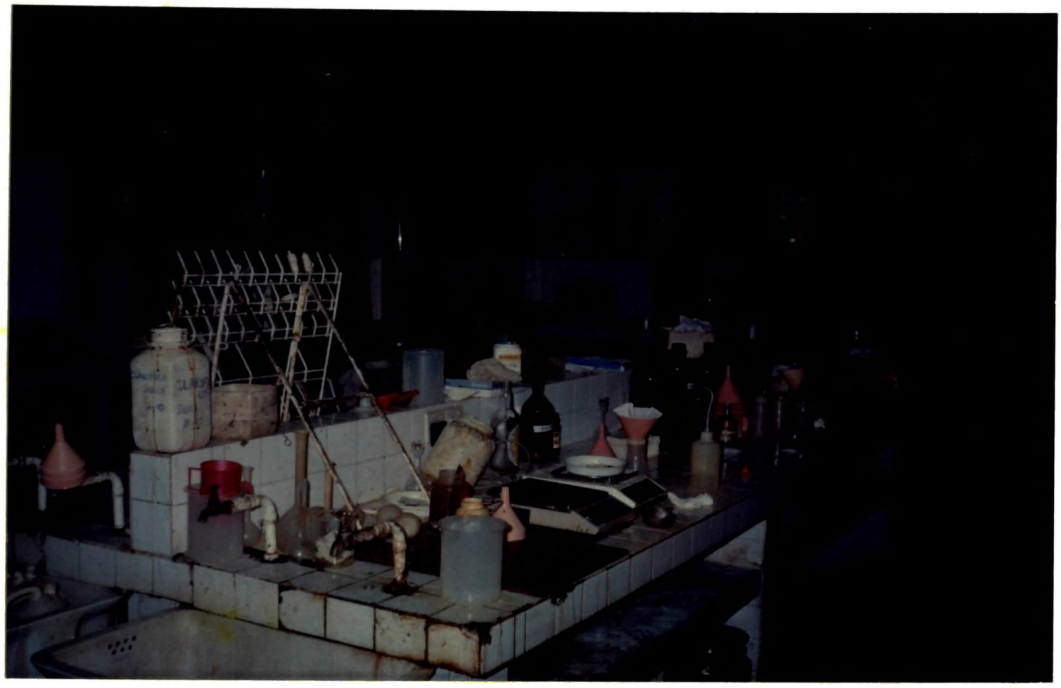


Figure 3.8 Laboratory Analysis

In terms of the sugar composition of cane juice, it contains high contents of sucrose than other sugar. But this high contents of sucrose is converted into glucose and fructose (reducing sugar),due to the activities of these micro-organisms and continuous respiration, that takes place even after harvesting. Therefore, the amount of sucrose is reduced and other sugars are increased because of these both activities.

The fructose and produced are combined to form a large polymerised compound called Dextran. This compound is also one kind of sugar. It has a characteristic feature that it can

multiply quickly by increasing the number of molecules. Therefore, the viscosity of this compound is normally high. Formation of dextran is a great challenge for the production of sugar and its formation should be reduced as far as possible.

3.3.1.2 The adverse effect of dextran.

* the major adverse effect is reduction of sugar quality.
* High percentage of molasses is lost.
* Considering the sugar formation, there is a certain size for the sugar crystals. But this crystal size is destroyed.
* Crushing ability is reduced and therefore gets delay in the pan stage.
* It is needed more times for the boiling stage.
* Centrifugal screens are clogged up.

3.3.1.3 The protection of dextran effects

As already mentioned, the dextran has as ability to multiply by increasing its molecules. Although the enzyme dextranze has an ability ti reduce the multiplication of dextran molecules. It has no ability to perfectly control the formation of dextran. Moreover this enzyme is very expensive and hence it is not used in Sri Lanka. But foreign countries that is this enzyme produce good quality.

3.3.2 Experiments

3.3.2.1 Determining the amount of dextran in the mixed juice

Purpose: _ This experiment was done to measure the quantity of dextran and to take some major steps to bring it under control.

Materials

* Beaker
* Burette
* Conical flask
* Test tube
* Buchner funnel
* Thermo metre
* Suction pump or vacuum pump
* Electronic metre
* Glass rod
* Trichloro acetic acid
* Pipette
* Volumetric flask
* Stand
* Measuring cylinder
* 420-890 mm filter paper
* No.5 filter paper
* comparator
* Spectro photo metre
* Table XV continued
* Stop watch
* Absolute alcohol

Procedure

* The mixed juice was collected continuously up to 8 hours to make possibilities of the experiment. This juice was mixed well and filtered thoroughly to remove the baggasilo.
* After that 60.00 ml of that filtered sample was measured out by using measuring cylinder and transferred into the conical flask.
* Then 2.00 g of mixed resin was added and shaken continuously for 10 minutes.
* The sample was filter once again and 50.00 ml of this sample was taken into another conical flask. Then 10.00g of trichloro acetic acid powder was dissolved in 100.00ml of distilled water. And 10.00 ml of this dissolved trichloro acetic acid solution was added into the sample and mixed well. Furthermore a litter amount of kieselguhr was added and mixed well. This compound makes easy for filtering.
* Then the sample was filter by using vacuum pump or suction pump.
* After the vacuum filtration, the filtered sample was

taken into two separate volumetric flask up to 12.5 ml

* Then absolute alcohol was pipette out and transferred into volumetric flasks up to making of the volume of 25.00 ml.
* During the addition of alcohol, it was continuously shaken. Likewise distilled water was added into another volumetric flask up to making of the volume of 25.00 ml. During the addition of alcohol, it should be added within a minute.
* These two samples were shaken well and kept in the room temperature.
* After that these two mixtures were transferred into two separate test tubes.
* Then these two sample tubes were put into the comparator and the colour different was observed.
* Then the weave length if spectra photo metre was set up at 720 nm and these two tubes were put into the spectrophotometer and the reading was noted.

Calculation

* At weave length 720 nm, the reading - 0.156
* The brix value of mixed juice - 15.20 ml
* The brix value from the table - 16.112 ml
* Dextran value from the graph - 2.8
* The value of the filtered sample - 12.5 ml
* The value of the filtered juice - 60.00 ml
* Temperature - 20^0C

$$\text{The correct dextran value} = \frac{2.8 \times 60 \times 20}{12.5 \times 0.16112}$$

Discussion

The harmless quantity of dextran is about 1500 ppm, If the figure rise up to the above level, the quality of sugar is affected.

3.3.2.2 Determining the Hydrazine amount in the boiling water

Purpose:- This experiment was done to find the availability of oxygen in the boiling water. As a result, the formation of corrosion is prevented.

Materials

* Beaker
* Comparator
* Hydrazine
* Pipette
* Test tube

Procedure

* First 5 ml of boiling water sample was measured into the test tube. Likewise, the same amount of Hydrazine was measured into another test tube.
* After that, these two samples were mixed together and then 10 ml of distilled water was measured into another test tube.
* Then 2 minutes later, these two tubes were kept in the comparator and compared the colour difference.
* Finally during the comparison, the reading was obtained from the comparator.

Discussion

The normal available oxygen in the boiling water is about 0.2. The possibility of corrosion in the pans would be high when this figure increases.

3.3.2.3 Determining the moisture percentage in the final bagasse (oven method)

Purpose :- This experiment was done to find out the percentage of moisture in final bagasse and to take steps to control this amount of moisture.

Materials

* Tray
* Stop watch
* Analytical balance
* Oven

Procedure

* First of all, the tray was weighed out by using analytical balance which the sample was kept.
* After that 100.00 g of bagasse was weighed out and kept in the tray by using analytical balance.
* The, it is dried at 105^{0}C by using electro oven for 3 hours until get constant weight.
* Then the tray was removed from the oven and weighed out quickly.

Calculation

$$\text{Moisture percentage in bagasse} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100\ \%$$

3.3.2.4 Determining the pol percentage in the final molasses

Purpose: - This experiment was done to measure the quantity of pol, which is lost with final molasses. and to take actions to minimise this figure.

Materials

* Beaker
* Analytical balance
* Conical flask
* Filter paper
* Lead acetic acid
* Pipette
* Measuring cylinder
* Thermo metre
* Polaris cope

Procedure

* First 50.00 g of final molasses was weighed out by using analytical balance, likewise, 50.00 ml of distilled water was measured out by using measuring cylinder and then,

both of these were mixed together well.

* Then 78.00 ml of mixed sample was measured out into the conical flask and 500.00 ml of distilled water was added into the sample and mixed thoroughly.
* Then after 11.00 g of lead acetic acid was weighed out by using analytical balance and added into the that mixed sample and filtered through the filter paper.
* Then 50.00 ml of filtered sample was measured out into the measuring cylinder and added 3.00 ml of lead acetic acid and 2.00 ml of distilled water making the total volume of 50.00 ml.
* Finally, the sample was poured out into the 200.00 mm pol tube and observed the reading by polaris cope.

Calculation

$$\text{Pol percentage in final molasses} = \frac{\text{Pol reading} \times 2 \times 5}{3} \times \frac{55}{50} \%$$

Discussion

The average quantity of pol percent lost with the molasses is between 25-30. The recovery of sugar would be very low when this figure goes above the level.

3.3.2.5 Determining the pol percentage in the final bagasse (Wet Disintegrator method)

Purpose: - This experiment was done to measure the quantity of pol, which is lost with the final bagasse and to take care to minimise this amount as far as possible.

Materials

* Analytical balance
* Conical flask
* Measuring cylinder
* Thermo metre

* Disintegrator
* Filter paper
* Standard pol table
* Lead acetic acid
* Disintegrator
* Polaris cope
* Stop watch

Procedure

* First 500.00 g of final bagasse was weighed out by using analytical balance and 5.00 l normal water was added with the weighed bagasse and mixed well.
* After that this mixture was transferred into the disintegrator and mixed well up to 30 minutes.
* Then after, 200.00 ml of above mixed sample was separated and filtered through filter paper. Then after filtering 200.00 ml of sample was measured out into the conical flask and a small amount of lead acetic acid was added into the conical flask to clear the sample.

* Then the clear sample was poured into 400 mm pol tube and put into the polaris cope and the final reading was obtained.
* Finally, the pol percentage was found out from the standard table, which was plotted against polariscope reading and moisture level of the bagasse.
* Or other way, the pol percentage in bagasse was found out by using calculation.

Calculation

$$\text{Pol percentage in the bagasse} = \frac{R \times 0.26 \left(100 - W \right)}{200 - \left(\frac{26R}{Q} \right)}$$

Here,

R ==> Pol reading of extract.

Q ==> Purity of residual juice.

W ==> Moisture percentage of bagasse.

Discussion

The average of pol value in the bagasse is between 2-3 and if this figure raise up to above this level, the recovery of sugar would be low.

3.3.2.6 Determining the total Dissolved Solid (TDS)

Purpose:- This experiment was done to measure the quantity of total dissolved solids in the boiling water.

Materials

* Beaker
* Glass rods
* Thermometer
* Conical flask
* Conductor metre
* Phenothaleine

Procedure

* First, 100.00 ml of sample was measured out into the beaker and then 2 - 3 drops phenothaleine was added into that sample and mixed well. It's colour was purple.
* Then after, certain amount oc acetic acid was added into the sample until the disappearance of the purple colour completely .
  At that time its temperature was measured out by using thermometer.
* Then that colourless sample was poured into the glass rod and put into the conductor metre. At that time sample temperature was adjusted in the conductor metre.
* Then, finally the reading was found out using conductormetre.

Calculation

$$\text{Total Dissolved solid} = \frac{\text{Conductivity Reading} \times 0.7}{1 - 0.002\,(20 - t)}$$

Here;

t ===> Sample temperature

Discussion

The average quantity of TDS in the boiling water is between 1300-1600. It should not be used the water, if the value is more than 1600.

3.3.2.7 Determining the pol percentage in the filter mud.

Purpose:- This experiment was done to measure the percentage pol which is lost with filter mud and to take steps to minimise this figure as far as possible.

Materials

* Analytical balance
* Conical flask
* Pipette
* Filter paper
* Thermo metre
* Beaker
* Polaris cope
* Lead acetic acid

Procedure

* First, 50.00 g of filter mud was weighed out by using analytical balance and added the distilled water into the that filter mud up to making the total volume of 200.00 ml.
* Then the certain amount of lead acetic acid was added into the sample and mixed well. Then that sample was filtered out through the filter paper. The filtered sample should be yellow in colour.
* Then, the filtered sample was into the 200 mm pol tube and put into the polaris cope and the reading was obtained.

Discussion

The average pol percentage in the filter mud is between 1.5- 2.0. The recovery of sugar would be low, when this figure passes this above level.

3.3.2.8 Determining the Brix value by using Hand Refractor metre

Purpose:- This experiment was done to determine the proper Brix value and to plan for the havesting programme.

Materials

* Refrctrometre (hand)
* Filter paper
* Distilled water

Procedure

* First, the glass lense of the hand refractor metre was washed well with distilled water and wiped out with filter paper.
* Then cane juice was taken from the cane and 2 - 3 drops of this cane juice was kept on the glass lens and the cover bottom was pressed.
* Finally, the reading was obtained by observing through the back side lens. it is the correct brix value of the cane juice.

Discussion

The Brix value of the juice of cane must be more than 16 to have a higher yield.

3.3.2.9 Determining the pol value by using polaris cope.

Purpose :- This experiment was done to find out the pol value of syrup, molasses, massecute and other stages of sugar processing.

Materials

* Polaris cope
* Beaker
* Pol value table
* Lead acetic acid
* Conical flask
* Test tube
* Filter paper

Procedure

* First of all, 100.00 ml of sample was taken into the beaker and 1.00 g of lead acetic acid was added into the sample and mixed well.
* Then, the mixed sample was filtered into the conical flask by using filter paper.
* After that certain amount of that filtered sample was poured out into the 200 mm pol tube.
* Then the pol tube was put into the polaris cope and obtained for incorrect value.
* After that, the correct value was obtained by using the pol value table.

3.3.2.10 Determining the Brix value by Abbey Refractor metre

Purpose: - This experiment was done to measure the Brix values in the juice.

Materials

* Test tube
* Beaker
* Thermo metre
* Brix value table

Procedure

* The glass plate of the metre was washed well with distilled water and wipeout by using filter paper.
* Then, a few drops of sample was taken on the glass plate and the incorrect brix value.
* Then the room temperature was also measured out by using thermo metre.
* Finally the correct brix value was calculated from the table which was pelted against fix value and temperature.

3.3.2.11 Sugar Trace (Sucrose content)

Purpose : - This experiment was done to find out the sucrose level, which was lost with boiling water.

Materials

* Test tube
* Alpa naptholeine
* H_2SO_4

Procedure

* First the tube was washed well with sample.
* Then 5 ml sample was measured and poured into the washed tube.
* Then 4 - 5 drops of alpa napthaleine was added.
* After that 5 ml of H_2SO_4 was slightly added along the wall of that test tube.
* If the sucrose present, the violet ring is formed. If not no formation of violet ring.

Discussion

The boiling water should be tested as soon as possible to minimise the quantity of and to increase the sugar recovery.

CHAPTER IV
RECOMMENDATIONS

The composed fertilizer can be prepared with the mixture of filter mud, filter cake and bagasse for the commercial purposes.

Care shoud be taken to remove the cane from the field as soon as possible after harvest to reduce the effects on the juice quality.

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