STUDY OF SUGAR CANE CULTIVATION AND SUGAR PROCESSING & LABORATORY ANALYSIS

By

U.L. ABDUL MAJEED

A project report submitted in partial fulfilment of the requirement of the advanced course

in

Food Science and Technology

For

The Diploma in Food Science & Technology
Affiliated University College
Buttala
University of Sri Jayawardanapura
Sri Lanka
1996

Approved By

Dr.T.G.A.Sisira
Senior Agronomist
Agronomy Division
Pelwatte Sugar Industry
Pelwatte
Sri Lanka

Date 26/10/96

Dr.K.K.D.S.Ranaweera
Programme Co-ordinator
Food Science and Technology
Actg. Head of the Department
of Physical Science,
University of Sabaragamuwa
Buttala,
Sri Lanka.

Date 05/10/96

Ms. K.M.Somawathie
Internal Supervisor
Lecturer
University of Subaragamuw
Faculty of Applied Science
Buttala
Sri Lanka.

Date 1996/10/29

AFFECTIONATELY DEDICATED TO

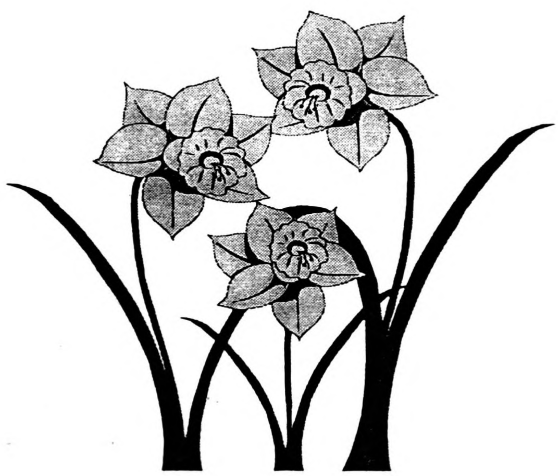
MY

FATHER & MOTHER

AND

EVERLOVING

BROTHERS, SISTERS & TEACHERS



ACKNOWLEDGEMENT

First and formost I wish to express my gratitude to my supervisor, Miss, K.M. Somawathie, lecturer, Department of Natural Resources,University of Sabaragamuwa, Faculty of Applied Science, Buttala, for her excellent guidance, kindness, sacrifice and invaluable assistance to complete this project report successfully.

I am grateful to Dr, K.K.D.S.Ranaweera, Programme Co-ordinator for Food Science and Technology, Acting Head of the Department of Physical Science, University of Sabaragamuwa, Faculty of Applied Science, Buttala ,for his invaluable guidance and assistance.

My special thanks go to Mr, M.A.Jagath Wansapala,lecturer,Mr.S.Rajadurai, instructor in english, University of Sabaragamuwa, Faculty of Applied Science, Buttala, for their invaluable assistance.

I wish to thank all the academic and non-academic staff of this University for their kindness and helps.

My deepest thanks go to Dr.T.G.A. Sisira Senior Agronomist, Mr,R.K.P.A Wickramasuriya, Crop Agronomist, and other field assistants and workers who work in the agronomic section of P.S.I.

I am also grateful to Mr, P.J.Premathunga, Production manager,Mr,Kapila Mendis, Chemist for their excellent and invaluable assistance regarding the processing and analyzing programme.

I wish to thank Mr.U.M. Najeeb, Agricultural services manager, Mr. M.Sherifdeen, Agricultural assistant suprendantant for their valuable assistance during the period of this project.

Finally my thanks go to friends who helped me in computerize this project report.

ABSTRACT

Sugar cane plays a significant role in the plant kingdom of the world.About 60 % of sugar is produced from sugar cane in the world. The growth of sugar cane is affected by several factors.They are environmental and cultural factors. Before growing sugar cane the factors such as the moisture content of the soil, nutritional condition of the soil,value of P^H ,temperature and the varieties of cane should be considered as important.In addition to it, the other factors such existence of pests and diseases, the rapid growth of weeds and other natural firing affect adversely the growth of sugar cane and its yield.The proper use of land preparation,planting methods, irrigation systems, fertilizer applications, weed control methods and the inter cultivation practices are the major steps should be taken in an appropriate time.

The capacity of sugar production and the quality of sugar depend on the quality of cane juice. The cane feeding,milling,purification,evaporation, crystallization and bagging are the six major steps the processing of sugar.A proper milling system is indispensable for the extraction of entire juice of cane as much as possible.The separation of molasses, filter mud and the bagasse are major by-products of sugar production.The by- products of sugar production are used for a wide range of purposes.Alcoholic products are mainly produced from the molasses. Bagasse is burnt in the boiler to generate power and the filter mud is used as fertilizer.

The laboratory analysis plays a key role in controlling the processing stages of sugar and determining the harvesting periods of sugar cane. Every stages of processing is analyzed at every single hour period in the laboratory of PSC.The dextran affects some processing stages and the quality of sugar greatly.The analysis of dextran is commonly done at weekly intervals in the laboratory of PSC. The higher quantity of Brix and Pol which are lost with molasses,filter mud and bagasse are minimized by this continuous analyzing of the programme.

TABLE OF CONTENTS

LIST OF TABLES.

LIST OF FIGURES.

CHAPTER 1

INTRODUCTION

Sugar cane plant takes a major part in the world's plant kingdom and among the cultivated crops of the world. Sugar cane grows in all tropical and sub tropical countries. Sugar cane cultivation is confined to the areas where within about 35 0 south and 350 north of the equator.Sugar cane originated in Asia, probably in New Guinea.Most important among cane growing countries are, Argentina, Australia, Barbados, Çuba, Egypt, Fiji, Florida, Formosa, Hawaii,India and Union of South Africa.

The crop flourishes under a warm, long growing season with a high incidence of radiation and adequate moisture followed by a dry,sunny and fairly cool but frost free ripening and harvesting period.Optimum temperature for germination (sprouting) of stem cuttings is 32-380 C. Optimum growth is achieved with mean daily temperature between 22-300 C.Maximum temperature for active growth is approximately 200 C For ripening,however,relatively lower temperature, the range of 20-100 care desirable , since this has noticeable influence on the reduction of vegetative growth rate and enrichment of sucrose in the cane.

The soils more suitable to sugar cane are clays and loams which retaining moisture, remain open enough to permit of proper aeration and drainage.Potash ,phosphoric acid and nitrogen are the principal nutrients required for the growth and good yield. The sugar cane is propagated either sexually by seeds or asexually by cane cuttings or setts.The buds on the stalk sprout and create a new plant.

The sugar cane consists os mainly roots, stalk and leaves.The indispensable part of sugar the cane considering the sugar production is stalk.The stalk of cane is built up of a series of internodes,separated from one another by hard portion walls called the nodes.The other shell of the cane is hard and is called the rind of the cane.The surface of the rind is coated with a kin of wax and the inside of the stem is called the pith. The pith is the soft,fibrous part of the cane and continuous in its cellular structure the bulk of the juice.

The major constituent of the cane juice is water and the next for water is the sucrose.The remainder of the constituent are reducing sugars,organic matters, inorganic compounds and nitrogenous bodies which are present in a little quantity.The only sucrose is used for the production of sugar and the other all sugars are also used in the production of jaggery.

The usual period of maturity differs from country to country and according to the climatic conditions under which the cane is grown. Generally it takes about 16 months for the proper maturity of plant cane and it is about 11-12 for the ratoon canes.About 3-5 ratoons are harvested for the feeding of factory and it can be had more than 5 ratoons, if the growing condition is good. Sugar cane has been grown in Sri Lanka since ancient times when it was used primarily for the medicinal purposes. During the colonial era systematic cane cultivation was under taken along the Gin Ganga in the Baddegama area for the production of jagger and syrup by boiling the cane juice in an open pans. With independence the necessity for the production of part of our sugar requirement locally was recognized and the first organized large scale cultivation of the crop was undertaken around a modern vacuum pan factory established at Hingurana in 1960. Today Sri Lanka has four factories located at Hingurana,Kantalai, Sevanagala and Pelwatte each with its own source of cane.

The present area under sugar cane (Saccharum officinarum) is about 13 million hectare with a total commercial world production of about 700 million tones of cane per year or 55 million tones of sucrose per year.

The annual production of Sri Lanka has been around 25,000 tones until 1985. with a commission of the two new factories at Sevanagala and Pelwatte there is now a potential for the annual production to increase to about 100,000 tones. This will still leave a gap of around 200,000 tones of sugar to be imported.

Therefore, there is a much scope for the future expansion of this industry in Sri Lanka, if self sufficient is to be attained.

The production of jagger from sugar cane as a substitute for sugar has been on wane in recent years.Its annual production now is said to be under 5,000 tones .

Pelwatte the largest factory, was established with a capacity of 2,800 tones cane per day or 47,000 mt of sugar per year.Cane is supplied from a Nucleus estates of 2,700 ha managed by the company, 1500 settlers families in a settlement estate of 3,600 ha and about 6,000 ha cultivated by private fare mars (out growers) in the area. The factory capacity is now being expanded to 4,000 tones cane per day or 70,000 mt of sugar per year.

The objective was to observe the procedures related to cultivation, crop management, harvesting , lab analyses and process of sugar cane

CHAPTER II

LITERATURE REVIEW

2.1 Classification and origin of the sugar cane

Sugar cane belongs to the family of graminae or Grasses. Sugar cane is one of the Genus Saccharum and Species officinarum of which there are an enormous number of varieties including wild types.

Kingdom	:	Plantae
Division	:	Angiouspermae
Class	:	Monocotyledone
Family	:	Graminae
Tribe	:	Andropogonae
Genus	:	Saccharum
Species	:	Saccharum officinarum

At present sugar cane is the most important plant from which sucrose is produced commercially.It generally accepted that sugar cane originated in New Guinea and neighboring South Pacific Islands where for many thousands of years it was grown for chewing , until recently there was no commercial sugar industry in New Guinea; the Islands have however,been visited by a number of expeditions seeking new genotypes for inclusion in commercial sugar cane breeding programmes.

The people of the South Pacific Islands undertook long sea voyages and among the foods which they carried was sugar cane which was thus spread throughout the Pacific and then to India and South East Asia.

It was in India that a crude form of sugar was first produced some 2000 years ago.

At that time sugar cane was spread to Persia (Modern Iran) ,Egypt and counties bordering the mediterranean sea.

The muslim conquests spread sugar cane further in North Africa and into Spain and Portugal.Indeed, sugar cane is still grown commercial in Southern Spain.

After the discovery of the Americas the Spanish colonists took sugar cane to South America and various Caribbean Islands where it formed the basis of the first modern era sugar producing industries.

The originating in the small groups of Islands sugar cane has been purposely spread by man until today. It is rare to find a tropical or sub- tropical environment in which it is not grown for the commercial production of sugar.

Sugar cane was introduced in Sri Lanka as a medical herb and history goes back to the ancient Ayurvedic periods

Increased development of sugar cane cultivation was evident during the Dutch invasion the Island.

When different variety were introduced from South India,Mauritius, Malaysia ,Indonesia and other South Asian countries, plantations were established along the Kelani, Nilwala, Kalu and Gin Ganga deltas.

The golden era of sugar cane commenced when the Dutch were succeeded by the British and the rapid expansion of the plantations took place particularly along Gin Ganga of Baddegama in Galle District. The first opened sugar cane industry was established in 1890 at Baddegama by E.D. Bowman and A.W. Winter.

The modern vacuum pan sugar industry was established in Sri Lanka with the construction of the Kantala sugar factory in 1960 , and since that time three more factories have been constructed, Pelwatte Sugar Industries Limited (P.S.I) being the most recent to established in 1986.

2.2 Morphology of sugar cane plant

The major vegetative parts of the sugar cane are the stem, root and leaves.

A. The stem

Like other grasses, the sugar cane plant has a long , joint stalk,also called the culm or stem .A small portion of the basel stalk remains under ground and this is referred to as the rhizome or root which is characterized by the presence of large number of buds present at closely spaced nodes.Roots emerge from this basel portion.Buds, leaves and other vegetative and reproductive structures develop on the above ground portion of the stalk.

The stalk is covered with a layer of wax, except in the region of growth ring (Artswager, 1330; Barnes, 1964). The wax is deposited in the form of white and densely crowded rods, changing to black when mouds grow on it(Dillewijn, 1952).

The stem is partitioned into nodes and inter nodes, varying in number, length and thickness in different genotypes of sugar cane.Under field conditions the stem may be attaian a height of 2-6 m,(Mr, Wendt,1988), and 1-4 m (Agnihotri, 1990), although occasionally it may be still longer. The diameter of cane may vary from 1.5- 6cm And 1-5 cm (agnihotri, 1990). Generally the girth of the stalk decreaces from the, middle part towards both ends.The length of an inter node may vary between 10- 25 cm. It can be changed by the environmental and by the pest and disease attack.

The shape of the inter node may be cylinderical, tumescent, bobbin, conoidal or concavo - convex (Barnes, 1964.) The colour of the rind varies in young and old internodes and is suallywhitish - green, yellow, green, red or purple. The colour of the internode is due to the presence of two pigments, namely anthocyanin and chlorophyll (Dillewijn, 1952).

The node is differeciated into four parts, namely, the leaf scar, root band, growth rind and bud. The leaf scar is that portion of the stalk to which the leaf sheath is attached. The root band is situated first above the leaf scar and may be narrow or broad.. It contains the root premordia or root eyes, their number varying appreciatly in different genothpes of sugar cane. Under proper growth condition, roots from lower 'eyes' develop first.

Just above the root band, there is a narrow band, called the growth ring. It is an inthercalary meristemic zone responsible for the elongation of the nodes. It seperates a node from as internode.

The growth ring is without a wax covering, and is colour alwayw different from that of internodes.

The bud is an embryonic shoot and 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.

A bud may be small or big, long or short. It may be ovate, obovate, round, oval, triangukar, pentagonal, rhomboid, rectangular or beaked. The charactor of the bud are of great diagnostic value in the classification of canes.

B. The Leaf

Each node bears a leaf and the leaves are arranged alternately on the stalk. A leaf has two prominent parts, this leaf sheath and the blade, with the joint known as the dewlap.

The leaf sheath is attached to the stem at the node and it completely encircles it with edges over lapping. 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 paralled veins are present.

The leaf blade may be broad or narrow, varying in width from 2.5 - 7.5 cm and in length upto 200 cm. it is broadest in the middle and gradually tapers off towards the leaf - tips to a sharp point. The blade has a prominent mid - rib and has numerous paralled veins on both sides. At maturing, there are atleast 10 functional leaves per stalk.

The crown or leaf cluster at the top of the stalk may be open or compact. The leaf margin is serrated or entire.

C. The Root

Sugar cane has a fibrous root system. There are two types of roots, namely the sett root and shoot roots.

1. Sett or Primary roots

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

2. **Shoot roots**

These are produced from the basal nodes of the young shoot and branch out into teritiary and numerous fine roots. Unlike sett roots, the shoot roots are thick, flishy and sparschy branched.

2.3. The life cycle of sugar cane

Sugar cane passes several growth stages in its life cycle, namely;

A. Germination phase

Subjected to all other circumstances being normal, a good germination may be considered as the basis for a good crop. Of the various factors involved in germination, top- dominance is the first to be considered. For the better germination the number of buds in a cuttings should be three (Babu,1990)

Germinability of the bud is positively correlated with the moisture and glucose content of the bud tissue , and adversely correlated with mineral content (Babu,1990).

The soil moisture content at the top 6" of the soil may be anything between 15 % and 25 % for good germination.Setts chosen for planting must be healthy and free from any diseases and peat attack.Shallow planting (1" to 2" depth) is most suited for germination (Babu,1990).

Moisture ,temperature,soil erosion and healthy seeds are the factors affecting germination.The quality of land preparation also plays a significant role in good germination.

B. Tillering phase

Good tillering needs adequate soil moisture ,fertilizer, optimum spacing and high intensity of light of maximum duration.

Light earthling up in early stage ie, 3 months age facilitates tillering while final earthling at about 5-5 1/2 month age smooth the late tillers.

Under conditions of low irradiance, low soil temperature and dry conditions emergence may be slow. Such tillers will be weaker and more susceptible to pest and diseases.

C.Elongation phase

Cane elongation also a significant phase in the life cycle of sugar cane. For what is known as grand growth or boom growth of the cane stalk, the favorable conditions are, hot, humid climate and higher moisture content. The good moisture favours above the wilting point.

more over, varieties differ in rate of growth. The rapid elongation occurs six to eight months of age depending on the quantity of available water and nutrient.

The elongation phase which is very important considering the formation of juice and the production of sugar.

D. Maturation or ripening phase.

The ripening of sugar cane is first indicated slowing down the growth, reached at a certain age and time of the year. When this happens the sugar produced by the plants gets stored in the stalk instead of being utilised in building new tissue. The ideal condition for this process are the age of crop, and cool and low humid atmospheric climate. Nitrogen starvation is another favorable stimulus.

More over, the ripening was associated with both incident sunlight and temperature, but not rain fall (Legendre, 1975 ; Babu, 1990)

E. Flowering phase.

Flowering phase is a phenomenon which may take place, generally, after vegetative growth is completed. It is apparently governed by hereditary and environmental factors. Thus varieties can be classified in to non-flowers, shy flowers and moderate to profuse flowers under a given favorable environment.

Among the environmental factors, which influence flowering, photo period is an important one. Sugar cane flowers all the year around at the equator, where the day-length is almost at 12 hours 7 minutes. The preferred day length by sugar cane differs from variety to variety.

2.4 Nutrition

To achieve maximum production or yield, the sugar cane crop must be able to obtain enough mineral nutrients from the soil.

considering the sugar cane cultivation, not like other crops, all the nutrients in the stalk are removed from the field.Therefore the addition of more nutrient to the soil is essential.

Application of macro - elements (mainly N.P.K)is generally through inorganic manures.However organic manures may be resorted to as initial support.

Sugar cane is a most exacting and exhausting crop.A crop of 125 tones per hectare removes about 83 Kgs nitrogen,37.2 Kgs of phosphate and 168 Kgs of potash from the soil.

These therefore must be present or replaced in assimilable form in adequate quantities within the root zone of the crop for the production of high yield.

Table 2.1: Nutrient content in a typical crop of sugar cane at harvest (Kg/ha)

Major nutrients	Stalk	Top & Trash	Roots
Nitrogen (N)	50	25	20
Phosphorus (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	-

Source:- Nutrition, (Journal, Pelwatte Sugar Industries) (Wendt, 1988.)

Table 2.2: Nutrition requirement in different growth phase

Growth phase	Period after planting	Nutrient required
Germination period	15-30 days	(N,P and K)
Early growth period	30-120 days	(N)
Active growth period	120-240 days	(N)
Maturation phase	240-360 days	Nil

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

Nitrogen Fertilization and recommendations at PSC.

The preferable N fertilizer in urea than ammonium sulphate.

Plant cane[maha] -40 Kg/ha N [90 Kg Urea/ha] at planting , buried with seed, plus 40 Kg N/ha at 7-8 weeks, before moulding.

Plant cane [yala] - 80J g N /ha [180 Kg urea/ha] all applied at panting time.

Ratoon [cultivated] - 80 Kg N /ha [180Kg urea/ha] applied along cane row before moulding.

P fertilization and recommendation at PSC.

" P" does not effect the juice quality though occasionally it causes slight reductions in juice purity. It is found about 0.2 - 0.8 percent of the total dry weight.

At" P" is applied only to plant cane, because of the doubtful benefits to ratoons.

Plant cane

80Kg of TSP /ha gives [32 Kg of p/ha, 80 Kg of P_2O_5] buried with seed cane at planting

"K" fertilization and reconmendations at PSC

"K" is required by sugar cane in larger quantities than any other nutrient. K accumulates in the leaves in early growth, and moves to he stalk [and juice] during ripening. Adequate K is essential for good juice quality. No K fertilizer is presently used at PSC.

Other sources of Nutrients.

A. Trash - trash and tops are also contain N,P and K in a certain amount in it. This amount of nutrients will be returned to the soil if the trash blanket is lift, but this represents only a partial replacement of nutrients remove byu the crop, not an addition of nutrients. Most of the K in the trash is in soluble form and will be leached out of the trash into the soil. N and K are mainly in organic form, and will only return to the soil while the trash rots down. If the trash is burnt,P and K will return immediately to the soil surface nut all the N; is lost to the atmosphere.

B. 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. 20 tones of filter mud/ha is incorporated to the soil during land development or redevelopment. I t provides about f200 Kg of N/ha, 120Kg of P/ha and 50Kg of K/ha to the soil.Most of the N and P is in organic form and will become available slowly as the organic matter breaks down. The K is immediately available for uptake byu the crop.

2.5 Pests of sugar cane

Sugar cane like any other cultivated crops subjected to the attack by pest resulting in the loss of yield,poor juice quality and low sugar recovery.Majority of the pests of sugar cane are insects.They cause damage to the plant by sucking juice,making galleries inside shoots and stalks,consuming stalks and seed materials and spreading of diseases etc,.

Diffeı ·nt species of insect were recorded from different cane growing areas. About 1300 species of insects associated with sugar cane have ben lifted from all over the world. Today about 60 species of insects were recorded as pest of sugar cane in Sri Lanka.

Apart from the insect pest, some species of parasitic nematodes and some species of mammals cause great damage to sugar cane.

To date there are about 18 genera and 50 species of nematodes have been recorded as pest of sugar cane from many part of the world. Lambery and Ekanayake,(1980) reported that 12 genera of nematodes were associated with sugar cane in Sri Lanka.

Damage to the young plantation by rabbits and to the mature plantation by wild elephants , wild boars and rats have been recorded from parts of the country

Table 2.3: Pests of sugar cane in Sri Lanka.

0-3 months after planting	**3-12 months after planting**	**Soon after harvesting**
* **insects**	* **insects**	* **insects**
1 termites	1 termites	1 termites
2 shoot borers	2 leaf hoppers	2 ants
3 thrips	3 stalk borers	
	4 mealy bugs	
	5 scales	
	6 root beetles	
	7 leaf eating caterpillar	
* **mammals.**	* **Nematodes**	

s	1 root parasite nematodes	
pines	2 free living ecto parasitic nematode	
	*** mammals**	
	1 wild boars	
	2 wild elephants	
	3 rats	

:- Important sugar cane pests (Kumarasinghe, 1988.)

illa perpusilla (Pyrilla leaf hoppers)

t is a major pest of sugar cane .It was recorded as an epidemic at Udawalawa in 1988 (Rajendra, 1968).

ecies of pyrilla are recognized from Sri Lanka,

a perpusilla and Pyrilla aberrance) . There are usually 3-5 generation per year.

re of damage:-

Both adults and nymphs of these species suck the sap from the leaves. The grown crop ted by leaf hoppers results deterioration in the quality of juice, low sugar recovery entage in the mills and quantity of yield.In case of severe infestation the sugar recovery fall into a level as 75% of the normal.

trol measures:-

Biological control is practiced by using egg parasites and predators. Manually hand king of egg masses is also practiced.

Moth borers :-

A. Sesamia inferns (Shoot borer)

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

Nature of damage:-

The larvae enters into the shoot by making a tiny hole in the lower portion of the shoot, resulting the dead heart.

Control measurers:-

Early planting prevents this attack. When the pest is prevalent in the large number the best method of control is by the introduction of egg or pupal parasites. In limited areas of infection the application of B.H.C powder 5.5 Kg per /ha into the soil or spraying 0.1% Endrin is recommended.

B. Chilo sachariphagus (Stalk borer)

Nature of damage:-

The borers feed mainly on the internodes and tunnel through the nodes. Damage may by found in any parts of the cane setts.Sucrose content of stalk is seriously affected and there is being decreased normal extraction of juice. The secondary organisms may increase the loss of sucrose to a significant extent.

Control measures:-

The most successful control measure advocated is the maintenance of weed free field and edges. No insecticide application is resorted. Because of the danger to the few natural parasites of borer larvae such as Megaselia spp,. (Saccharicoccus sacchari) Mealy bugs.

Pink mealy bugs.

Nature of damage:-

They weaken the plants by sucking the sap. Severe infestation of the bugs are said to cause problems in the factory during filtration and clarification of juice.

Control measures:-

The effective control achieve by cultural control, by using of the pest free seed cane. Chemical control method is not economical but use of B.H.C , Aldrin ,Dieldrin and Folidol.The biological control measures are also practiced.

Termites:-

Nature of damage:-

There are three periods where the most termite damage occur.

1.Soon after planting - they hollow out the sett causing germination failure.
2.When the cane begins to ripen,growth cease and pass through lengthy dry periods.
3.After harvesting.

Control measures:-

Removal of free stumps and roots from soil in the case of heavy infestation and insecticide like Aldrin, Dieldrin could be poured down the mounds.

Others:-

Nematodes:-

These are microscopic worms which inhibit soil in large number under varying climatic and soil conditions.

Mammalian pests:-

Wild pigs and elephants do the biggest damage and utmost care should be taken to prevent their access to the plantation.

2.6 Diseases of sugar cane

1. Fungal diseases:- Smut, Pokkah boeing, red rot, Pine apple disease.
2. Bacterial diseases:- Ratoon Stunting Disease {RSD}, leaf scald, red mottled/stripe
3. Viral diseases: _ Sugar cane mosaic viral disease [SCMV].

01. Fungal Diseases.

A. SMUT:- caused by Ustilago scitaminae.

Symptoms of SMUT:-

The parent symptom of the disease in the production of a black whip like structure from the central core of the meristematic tissue.

In the initial stage, the whip like appendage is covered with a silvery ;membrane which when ruptured numerous spores of fungus are disseminated by the wind. The infected shoot, before forming the whip, starts putting out lying internodes and short leaves resembling its flowering stage. It heavily infests the ratoon crop and exhibits grassy appearance.

Sugar recovery is reduced by 40-90 percent by this disease. "The plants affected in the early stages dry up. The spread of the disease is due to infected seed cane. The ratoon crop of cañe serves as carrier of disease in the sugar cane areas.

Control measures:-

1. Rouging the attested clumps.

2. Smut whips may be collected carefully and destroyed by dropping the whips in boiling water

3. Spores may be destroyed by burning the whip along with trash

4. Healthy seed of approved resistant varieties may be encouraged.

5. By adopting crop ratooning method.

6. Hot water treatment of seed cane at 52_0 C for 20 minutes.Dipping setts for 10 minutes, in hot water at 55 - 60^0 C before planting [Mathur, R.B.L,1993].

7. Disinfection with 0.1% mercuric chloride solution or with 1% formalin solution for 5 minutes, followed by two hour covering under a moist cloth in the case of formalin [Mathur,1993]

Co 775 is moderately susceptible to smut while M 377/56 is highly susceptible, varieties Co 997, M 351/57 are resistant varieties to smut.

Symptoms of Red rot:-

The red coloured patches may be seen on the mid rib of the leaf, inside the stalk etc,. Withering and drooping of leaves starts from the tip to the base of the leaf until the whole crown withers and the plant dies. Gradually the stem rots and the central tissue becomes pithy.

Control Measures:-

1. The affected sugar cane should be harvested, followed by digging up of stubble and burning it along with trash.
2. The use of healthy seed of approved resistant varieties is suggested.
3. Proper drainage must be ensured is the field.
4. Field sanitation is important for checking disease.

Moreover the diseases like Pokkah boeing and Pine apple disease are caused by Giberella fujikuroi and Ceratocystic paradox respectively and these diseases cause damages to sugar cane at PSC.

B. RED ROT:-

Caused by Collectotrichum falcatum [Perfect stage is Glomerella tucumanensis]. It is not a serious problem at PSC though it seems to be present at a very low intensity all over the plantation.

2. Bacterial Diseases.

A. Ratoon Stunting Disease [RSD]:-

It is caused by Clavibacter xyli. The disease has been reported from 41 out of the 102 sugar cane growing countries in the world. This disease is responsible for the so-called `deterioration' or `stunting out' of several commercial varieties [King, 1950, King and Steindi,1953, Abbott, 1959, Steinds,1961; Steib and Chilton, 1956,1968].

The typical RSD symptoms have not been seen in PSC cane though the bacterium responsible for the disease is reportedly present in many of the canes sampled.

Symptoms of RSD :-

diseased stools usually display stunted growth,reduced tillering,thin stalk with shortened internodes and yellowish foliage. No abnormality is seen either in the root system or in the underground buds and portions of stalk.

Typical symptoms are seen only after split opening of the cane longitudinally. Orange - red vascular bundles in shades of yellow- orange , pink,red and reddish brown at the nodes have been observed in many varieties [Agnihotri, 1990].

Control Measures:-

Use of healthy cuttings and disinfection of tools [cane knives and harvesting implements] at short intervals and long hot water treatment of seed cane ie,50.5^0 C for 2 hours.

B. Leaf Scald :-

It is caused by <u>Xanthomonus</u> <u>albilineans</u>. This disease has been responded from 37 out of 102 sugar cane growing countries in the world [ISSCT,16^{the} congress, 1976, Agnihotri,1990.

Symptoms of Leaf Scaled :-

In the acute form of the disease, the affected plant will die suddenly without showing any symptoms.

In the chronic form leaves will develop typical pencil lines along the leaf blade which are white to yellow in colour. The lines may extend up to the leaf sheath. Under heavy infestation, proliferation of side shoots followed by death of the whole plant is encountered.

Control Measures:-

Use of resistant or highly tolerant varieties. Use of disease free cuttings from the nurseries. Disinfection of knives and other tools. Long hot water treatment at 50^0 C for 2 hours.

3. Viral Diseases.

A. Sugar Cane Mosaic Virus [SCMV].

This is the common disease that can find in PSC. Virtually every single plant is infected. But mosaic is one of the most potentially dangerous diseases of sugar cane and is widely distributed in the sugar cane world [Agnihotri,1990.

Symptoms of SCMV :-

The characteristic symptoms of the disease appear more prominently on the basal portion of younger foliage then on the older ones. Generally chlorotic or yellowish stripes alternate with normal green portions of the leaf giving a mosaic pattern.

The disease causes varying degrees of destruction in the chlorophyll content of the foliage and the loss is treated with the variety and strain of the virus involved.

In the highly susceptible varieties yellow stripes develop on the rind of the internodes, while in other varieties tissues cell,apse and stalks finally dry up resulting in `sunken' areas known as the `canker stage' of mosaic [Agnihotri,1990].

Control Measures:-

Rouging of infected stools which is not practicable under our condition [due to 100% infection level]. Growing of resistant varieties and hot water treatments are practiced.

CHAPTER III

OBSERVATIONS

3.1 Observation on sugar cane cultivation and crop management.

3.1.1 Land preparation.

The land development section is responsible for the preparation of all land for planting. The most important part of land preparation consist of the primary operation of opening up and ploughing the land.While opening up or ripping of the soil helps in aeration, water penetration and root development as already said,ploughing facilitate weed destruction, build up of soil organic matter and ensures good tilth and germination conditions.

The land preparation operations are done by manual labour, traditional bullock/horse drawn and by tractor implements.In PSC, it is being achieved by only tractor implements than the manual operation. After the planting, inter-row cultivation and inter-cropping practices are also enable to development of soil condition and water penetration.

In new land, first operation involves the clearing of all trees and bushes using bulldozers. All material recovered is stacked and burnt. The land is then ripped, ploughed and harrowed. After this preparation the farrows are made and the fields are ready for planting.

Ploughing or Ripping

If there is sufficient soil moisture for a heavy plough to penetrate to a depth of 15-18" ploughing of the land is generally the rule and this ploughing is followed up with a cross ploughing. Ploughing is done with the use of majestic ploughs or Rome ploughs where the discs are of 32" diameter.

Harrowing

When ploughing or ripping is done, there will be large clods of soil which have to be broken up. This done by harrowing Heavy duty Rome Harrows carrying 16 discs of 30-32" diameter per gang are used for this purpose. To ensure that all the big clods are broken down harrowing is followed with a cross harrowing.

Planning

After harrowing, the land planning becomes necessary in order to get a smooth surface to facilitate proper harrowing. The equipment used for this purpose is a planer 60' long and 60' wide. This is done in the direction of the natural land slope.

Furrowing

The land is furrowed at 1.5 m spacing with equal width of furrow and ridge . The furrows must be straight and evenly spaced . For the planting of sugar cane, furrows of 9" depth are preferred. When the implement moves, the shanks cut into the soil and the two mould boards throw out the soil into either side leaving the furrow open.

3.1.2 Nursery operations

The basis of a good cane crop is an efficient planting programme and that programme depends entirely on the use of well grown seed cane.

At Pelwatte the main source of seed cane are the seed cane nurseries and some of the Nucleus Estate commercial cane areas. Most seed comes from the nurseries.

All cane grown in the primary nursery is from seed which has been treated against Ratoon Stunting Disease (RSD). This is done by treating the seed in a tank of water heated to 50.5^{0}c for a period of two hours.

Cane from the primary nursery is used for planting of secondary nurseries. All nurseries are irrigated.

Nursery operations are basically practiced as in general farming but crop husbandry is much more detailed, irrigation is a standard practice and most seed cane will be harvested at 6-9 months of age to vive a vigorous, succulent seed piece.

Land preparation

This may be done by deep ripping followed by two or more ploughing and disc harrowing.

Seed cane

The seed cane used in ;planting will come from :-

(1) The primary nursery:

seeds of new varieties or existing primary nursery. All seed for planting the primary nursery will have been hot water treated against RSD at 50.5^{0}c for two hours.

(11) The secondary nursery:

All seed cane will come from the primary nursery only.

Planting in the nursery:

The density of planting setts are higher than that of commercial field, because double line continuous method is practiced in the nursery whereas single and 50% overlapping methods are practiced in commercial fields. About 7-12 tones of seed cab is adequate for one hectare of land. Due to higher density of cab crop the size of all the stalks may be equal . The space between two rows may vary from 1.3 m - 1.5 m.

Time of planting

Table 3.1 : Time of planting in the nursary.

Nursery	**Maha**	**Yala**	**Purpose**
Primary	July	February	Later secondary use
Secondary	Feb-March	September	Later commercial use

Source :- Field operation manual, 1988.

Fertilizer Application

Fertilizer application 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 the seed cane areas about 6 weeks before the planned seed cane harvest. The cane with a high nitrogen content will geminate better than canes grown under poor nutritional conditions. This fertilizer application may also be made to those commercial fields where the seed cab is obtained.

Fertilizer application on ratoon cab in the nurseries is similar to commercial ratoons plus the top dressing of 50 kgs of Urea per hectare 6 weeks before harvest.

Disease control

Regular inspection, rouging and the general use of all regular preventive practices such as the sterilizing of cane knives and the fungicidal dipping of cane setts are practiced in the nursery.

By applying hot water treatment at 50.5^{0}c disease like smut and GSD can be prevented. Under this practice, the disease smut is controlled perfectly than that of GSD.

By treating the seeds with hot water at 52^{0}c for two hours, all the disease agents can be controlled but, the percentage of germination is about 40% whereas 60% at 50.5^{0}c (Wendt,1988).

Before planting all the seed should be treated against the diseases such a s pine apple disease and fusarium rots. By dipping them in a solution of Benlate (100 g of Benlate in 75 liters of water). It is only necessary to dip the seed piece quickly in and out of the solution.

Ratoons

Seed cane production in nurseries will generally be of plant and first ratoon only. Second ratoons may be kept where crop condition looks good. No ratoons beyond second should ever be considered as a precaution against the incidence and spread of sugar cane diseases.

Irrigation

All seed cane nurseries receive full irrigation treatments where that is possible, The cycle will vary with the age of the crop and the subsequent amount of canopy formed by the crop.

As a general guide the following will apply on newly planted areas.

in 1 day - 75 mm

in 13th day - 37 mm

in 19th day - 37 mm

From then to half canopy; 75 mm in every 21 days.

From half to three quarter canopy; 75 mm in every 16 days

From then to full canopy; 75 mm in every 13 days

Full canopy onward; 75 mm in every 10 days

All irrigation practices are done at PSC by sprinkler irrigation system. Water sources are the Menik ganga, Kuda oya, Kirindi oya and the factory effluent tank.

Weed control

Chemical weed control in the nurseries follows the guidelines of commercial operations.

Harvesting and Transporting

Harvesting is done 6- 8 months after planting. The cane which is more than 9 months in age and possess developed buds and roots are not suitable for planting.

Cane cut should be topped, left untrashed and placed 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 transporting.

Seed should be transported carefully over the minimum practical distance and unloaded by the best of practical means

3.1.3 Plant cane operations

Planting

This can be taken place either manually or mechanically,the objective being to locate the cane setts in the ground which will be capable of producing subsequent ratoon crop for an additional 2 or 3 years.

Planting material

The sugar cane can be propagated either by using seeds or by using piece of stem.But the seeds are very small in size and most of the varieties do not make fowering. Therefore, the sugar cane plant is reproduced through buds on the stalks.The whole stem can be used but, the disadvantage is uneven growth of the plant.Thereby the piece of stalk containing 2-3 buds is planted as cuttings or setts. The buds on the upper portion of the stalks germinate better than those on the lower if the stalk is mature.The half top portion of the stalk could be used as seed cane if the stlaks are old.

The size of the bud should be small in size and the root must be at undevelopped stage.The length of the inter nodes must be quite long, otherwise the tillering would be very high and as a result the density of the plant would be higher.

When to plant

There are two distinct planting periods used at PSC Maha and Yala.

The Yala planting is done in March/April. Both periods may be started earlier and finished later and timings will depend entirely on the rain fall pattern an d soil moisture levels.

Where to plant

The planting system to be adopted could vary depending on whether it is practiced under irrigated, rainfed or poorly drained conditions and according to topography and drainage. The common methods under all conditions is to plant on the ridge and furrow system. In shallow soils the furrow should be 10-15cm 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 beformed making use of the steepest slope avilable and planting should be done on ridges.

Figure 3.1 Sugar cane planting.

Pre- planting spray

This spraying is done as a weed control measure on land which has been prepared and furrowed well before planting time.The composition of the spray can vary dependant on when planting will take place and the state of any weed growth in the field.

Generally spraying will be done,

if planting is expected within 4 weeks after land preparation

2 Litre/ ha Paraquat

2 Litre/ ha 2, 4-D 720 Amine

mixed in 220 litre of water or,

Where planting may be delayed upto 8 weeks

2 Litre /ha paraquat

2 Litre /ha 2,4-D 720 Amine

3 Kg /ha Diuron

mixed in 220 litres of water.

- In both cases Paraquat will be used if weeds are started to germinate and have reached the 3 leaf stage.

Seed cane cutting

seed should be cut at or b elow ground level on the bottom and just below the growing point at the top. The seed is left untrashed and carried in budles to the field.

The cane knives must be sterilized regularly soaking by over night and then regularly dipping in container of the disinfectant kept in the work area.

The mixture used is based on <u>Formalin</u> and is made up to a 1% solution of <u>Formaldehyde</u> (100ml in 10 litres of water.)

Basel application of fertilizer

Supplies of urea and Triple super Phosphate (TSP) are arranged for delivery to the field for each days planting.

There is a variation in the rates of fertilizer application in Maha and Yala planting. This is because in Maha plant sufficient moisture is available to allow a second- or top dressing application at 6 weeks after planting.

Such suitable moisture conditions are unlikely to exist for Yala planted cane and therefore the whole dose of urea is applied at planting time.

The fertilizer application rates are;

For Maha plant	**For Yala plant**
90 Kg /ha urea	180 kg /ha urea
180 Kg/ha TSP	180 Kg /ha TSP

The fertilizer must be applied evenly along the furrows and ideally it will then scattered below and beside the cane sett by the action of the labourers when the furrow is closed.

Preparation of cane setts

The seed canes have the trash removed by hand and are placed in a stack ready for chopping.

The cleaned canes are chopped into cane setts or piece of seed usingm a straight knife again st a block of wood. Setts will be 40 -50 cm long and will contain 3 or more eye buds.

After chopping the setts are placed in a dipping basket and quickly dipped into a half drum containing a solution of BENLATE (100g of Benlate mixed in 75 litre of water). The ends of the setts require thorough wetting, there is no need for a lengthy immersion. Total requirement of 200g BENLATE is perhactare.

Seed placing

The treated setts are then placed alomg the bottom of the furrow.There are 3 patterns of seed placement as,

1. Single line continuous method
2. Double line continuous method
3. One and half overlapping method.

This can vary dependant on seasonal conditions and seed quality.In nursery planting an overlapping of 100% is always used.

Covering is done manually using a mammoty to bring to loose moist soilfrom the furrow sides on to the cane setts. The depth of covering woll vary, depending on the weather conditions.If good moisture is present and rain is expected then 5cm is sufficient. If conditions are drier and raiv can not be expected the covering should be increased to 10 cm

Then the soil is compressed a little by the pressure of the feet of the covering labour. In very dry conditions compaction can be done by running a light tractor over the n ewly covered cane rows.

Pre- emergent spray

This is done in the week after planting. Two different spray mixtures may be used.

If ground conditions are clean and there are a few young weeds the mixture is;

2, 4-D Amine, 2 Litre/ha or

Diuron,3 kg/ha

mixed in 22o litres of water

If young weeds have begun to emerge and are reaching the 3 leaf stage, Paraquat, 2 litre/ha may be added to the mixture. When using Diuron it is important that the powder be mixed into a paste with water before putting into the herbicide bowzer. An agitation pump must be used in the bowzer when using Diuron mixtures.

Gapping

Gapping is the term used for filling in the empty spaces left in the rows of new cane crop by poor germination, pest attack etc..,.In general gaps of 1m or more will be replanted.As germination can vary from year to year and from field to field no definite percentage to be gapped can be accuarte- a general guide for planning purpose would be 10% of all planted area.

The row gap must be furrowed by hand to sufficient depth leaving a good bedof loose soilin the bottom and at the sides of the furrow.

Fertilizer is added and after the setts have been placed they are covered with 10 cm of soil which is compacted with the labourers feet. All opening of the furrow, fertilizing, planting and covering must be completed with a same day. The gaping is about 5 weeks after planting.

Top dressing of fertilizer

This applicationn of fertilizer is done 6 wees after planting.Generally a fertilizer top dressing of urea is applied only in Maha season. Because of an anticipated lack of moisture at week 6 of the Yala planted cane no top dressing may be applied.

The only fertilizer top drssing generally used on plant cane is urea at a rate of 90kg/ha. Placement of the urea is directed again along the bottom of the still open furrow - along and adound the young growing cane shoots.

Mechanical cultivation and mechanical fertilizing

The cultivators at present in use in plant cane are of two types;

1. The Ransome spring tyne which is fitted with 8 short straight tines. It can cultivate two rows at a time.

2. The Simba tool bar fitted with 8 coil types also has the capacity to cultivate two rows at one pass.

Figure 3.2 Inter cultivation of sugar cane plot

Depth of working in plant cane is aroun 10 cm which gives some effective weed control, leaves the interrow surface in good condition and from the action of the t8ines throws some soil into the acne row to effectivly cover the urea. Late planted Yala cane may not beinter-row cultivated if soil conditions are vary dry.

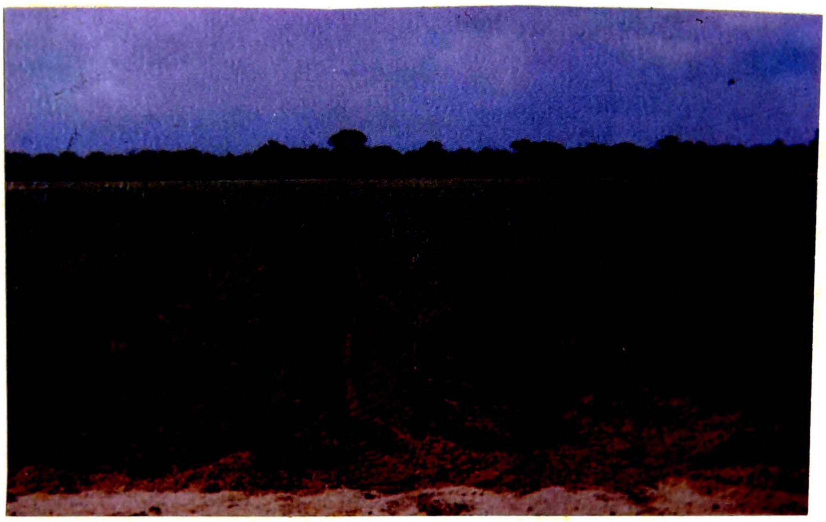
Mechanical fertilizer distributors can be fitted to these new units which will allow fertilizing and cultivation to be completed at the same time. Advantage of this system will be that fertilizer can be applied into the ground in the area where it is best available to the growing plant.

Mechanical moulding

This moulding activity is done 9 weeks after planting Moulding up is generally carried out by a machine mounted disc implement. The disc run along and between the cane rows and throw soil from the interrow area onto the cane row. From a furrow to a slight wide ridge about 15 cm high, along the line of the young cane stools where cane is planted on the ridge a higher ridge is acceptable.

The timing of the operation is important. Too early will inhibit the tillering - too late may cause damage and break cane stalks.Nine weeks is a general time guide but once again conditions and seasons can cause minor changes. All of the young plant would be moulded by machine if possible.

Figure 3.3 Cane field after moulding



Manual moulding

In those areas where a machine can not be used the operation will be carried out by hand, using a mammoty soil is taken from between the rows and placed on and around the cane so as to form a ridge about 15 cm high. The middle of the interrow should be left sufficiently smooth to allow surface water to run off.

Post -emergent spray

This weedcontroloperation follows immediately after the moulding up operation and certantly no more than 3 weeks after moulding . Effectiveness depend on soil moisture conditions and these conditions will generally prevent spraying of the Yala planted crop- except in very early planted areas. Most Maha plant will be able to be sprayed.

The mixture used will be;

2, 4-D Amine,2 litre/ha and

2 Litre /ha Paraguat

Mixed in 220 litres of water.

If the soil surface is covered for more than 40 % by weeds the 2,4-D Amine will not be added to the mixture and paraquat only be used.

Hand weeding (16 weeks after planting)

The first weeding by hand will take place at 6 weeks after the post - emergence spraying. It consists of the uprooting of all weeds in the cane row, the inter spaces and the field edges. After the weeding the land should be reasonably free of weeds for about 3 weeks. The timing of the operation acn vary with a season and with weed growth. Generally this first weeding will be most thorough and 100% of the area will require weeding.

Hand weeding (20th and 24th week after planting)

The final operation on the plant crop are both manual. The second weeding follows the first by 4 weeks. The third and final weeding again 4 weeks later in week 24.

In both late weedings particular attention must be paid to guinea grass and to young creep vines. If they are neglected at this stage they can bebome a major problem by harvest time.

Harvesting and Transporting

Harvesting time is determined after the testing of maturity index of cane in the laboratory of agronomic section. The cane field is fired before harvesting to facilitate and quicken the harvesting activities. The harvesting of cane including nursary is being done by manually. No mechanical harvesting is being done at PSC. After removal of tops and trashes, the cane is stacked, loaded and transported to the feeding section of the factory.

3.2 Observation on post harvesting of sugar cane and manufacture of sugar.

3.2.1 Post harvest technology.

The quality of cane juice is affected by several factors. They are environmental, cultural and mechanical factors. The loss in quality of juice is higher in the fired cane than that of harvested without firing. Out of 10% total quantity of juice is lost during fired harvesting. The temperature of environment also causes severe effects on juice of cane. About 8-10% of juice is lost in a period of 24 hours after harvesting. There is a formation of cracks on stems when the cane is fired. Thereby, certain kind of harmful micro-organism enter through this cracks and cause adverse effect on juice of cane. Any way, 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 Factory operations and making sugar.

When we consider the sugar production from the sugar cane, there are six major steps as follows;

1. Cane feeding
2. Milling
3. Purification
4. Evaporation
5. Crystallization
6. Bagging

Cane feeding

It is the first step in the processing of sugar. The cane is loaded into steel open containers (capacity 8-10 tones) by the use of machine. The cane is directed to the cane feeder table. The kicker has been fixed in the feeder table to make evenness of the cane to reduce the difficulties in the cutting section. About 150-175 tones of cane is fed into the table per hour.

The feeder table is a platform which carries the cane forward until it falls into the cane carrier.

The cane now passes through two sets of knives which are rotating continuously and the cane is cut into small particles. The second knife cuts the cane into more small particles than the first knife does. Then these cut particles are conveyed underneath of the shredder and the particles are chopped by this shredder. Then these chips are passed to the first mill operation.

Figure 3.4 Cane is fed in the factory.

Milling

In PSC, there are four sets of mills and each mill contains top, delivery and feed rollers. The shells grooved 45 degrees at 50mm pitch to increase the surface of the rollers.

The cane is then crushed twice, first passes between the top roller and feeder roller, then it passes between the top roller and delivery roller. Then the juice flows between the feed roller and delivery roller.

The top roller is hydraulically loaded to approx 500 tones and can float to 32mm. This applies an even pressure to the cane blanket and squeezes out the juice. The cane is squeezed twice in each mill and the ration of openings in approximately 2:1. Thus at PSC the cane is squeezed eight times in all.

After the removal of juice, the fibre acts like a sponge which is called bagasse. Normally the first mill bagasse passes through the second mill and the second mill bagasse to the third mill. When the bagasse comes out of third mill, imbibition water is added in order to maximize the extraction of juice. Then the bagasse which is added water enters to the fourth mill.

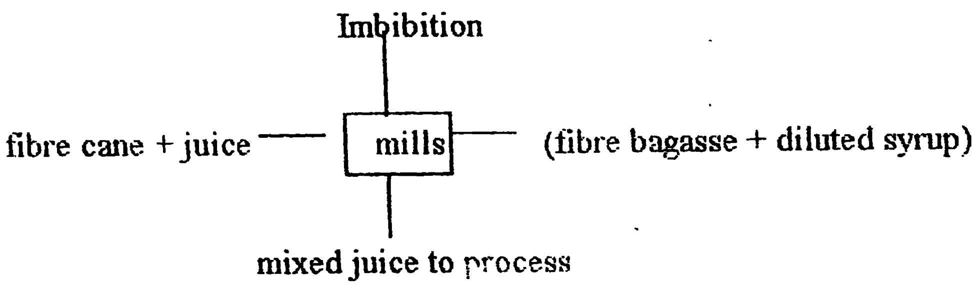
It would be impractical to add water in front of every mill as all this water would have to be evaporated later on. So, the juice from the fourth mill is added before the third mill and the third mill juice is added before the second mill. Thus the juice is concentrated at the first two mills.

The juice from the first and second mill is collected and passed over a screen to remove bagasse particles before flowing to the mixed juice tank. This tank is fitted with bottles and a 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.

The bagasse conveyed to the boilers where it is used as a fuel to generate steam. This steam is then used to drive the mill turbines and the turbo alternators which provide electricity for the factory and the estates.

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

A 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 the amount of sugar is burnt in the boiler instead of going in the bag.



$$\text{Mill extraction} = \frac{\text{Tones sucrose (pol) in mixed juice}}{\text{Tones sucrose (pol) in cane}}$$

Tones cane + Tones imbibition - Tones mixed juice = Tones bagasse

Purification

The mixed juice from the mill is passed to the process house and weighed in the juice scale automatically. The weighed mixed juice is sent to the clarification section to remove impurities as early as possible in processing.

In the clarification stage after heating them juice to about 65-70^{0}c in the first stage juice heater, the juice is limited to a P^H above 8.5. In this high temperature all the inorganic matters are removed as gases and steams.

Then the juice moves to the sulphatation tank to contaminate with so_2 gas.This so_2 gas bleaches the juice and make clear the juice. After the sulpahtation, lime $ca(OH)_2$ is added to the juice again and pumped into the clarifier via secondary heaters. The clarifier has four compartment which are like four settling tanks placed on top of each other.

This liquid is allowed to settle for certain time. The impurities settle at the bottom and form a mud which is very gently escaped to the centre and removed out of the filter station.

The mud that settles at the bottom of the clarifier now contains part of the impurities which we don't want in the sugar. The clear juice is called clarified juice. Clarification helps to extract a large quantity of juice, and this juice contains sucrose.

A little amount of juice is left with mud. Rotary vacuum filter are used with the help of bagassilo to separate juice from this mud. This mud is called filter cake. This filter cake is separated by vacuum filters. This cake is taken out by conveyers from the factory and used as a fertilizer.

Evaporation.

Then the clear juice (juice + water) is sent to t he evaporators to remove the water from the juice. The evaporators are large vessels which are interconnected with vapor lines. There are five large evaporators are available at PSC. By the time, the clarified juice has left the final vessel, it has lost a great deal of water and consist of at least 65% of dissolved solid which is called syrup.

The syrup then passes to the vacuum pans. A pan is a evaporating vessel for boiling four syrup to form a high viscosity substances, called massecute. Which is a mixture of crystals and molasses. This is done by evaporating of water from the syrup, leaving behind the sugar and impurities. It is very important to boil the sugar material under vacuum to avoid caramalization.

Crystallization

From the vacuum pan the massecute does not go directly to the centrifugal separates. It first flows to a crystallizer where the crystallization is occurred and contain to grow as it cools by taking up sucrose from the mother liquor.

The 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. Finally the sugar is passed on the horizontal type rotary drier and dried at 65^0c. It is very essential to maintain sugar moisture at 0.06-0.07 in order to produce good quality of sugar. Then the dried sugar is transferred into large containers (sugar bins)which are connected to bagging machine.

Bagging

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

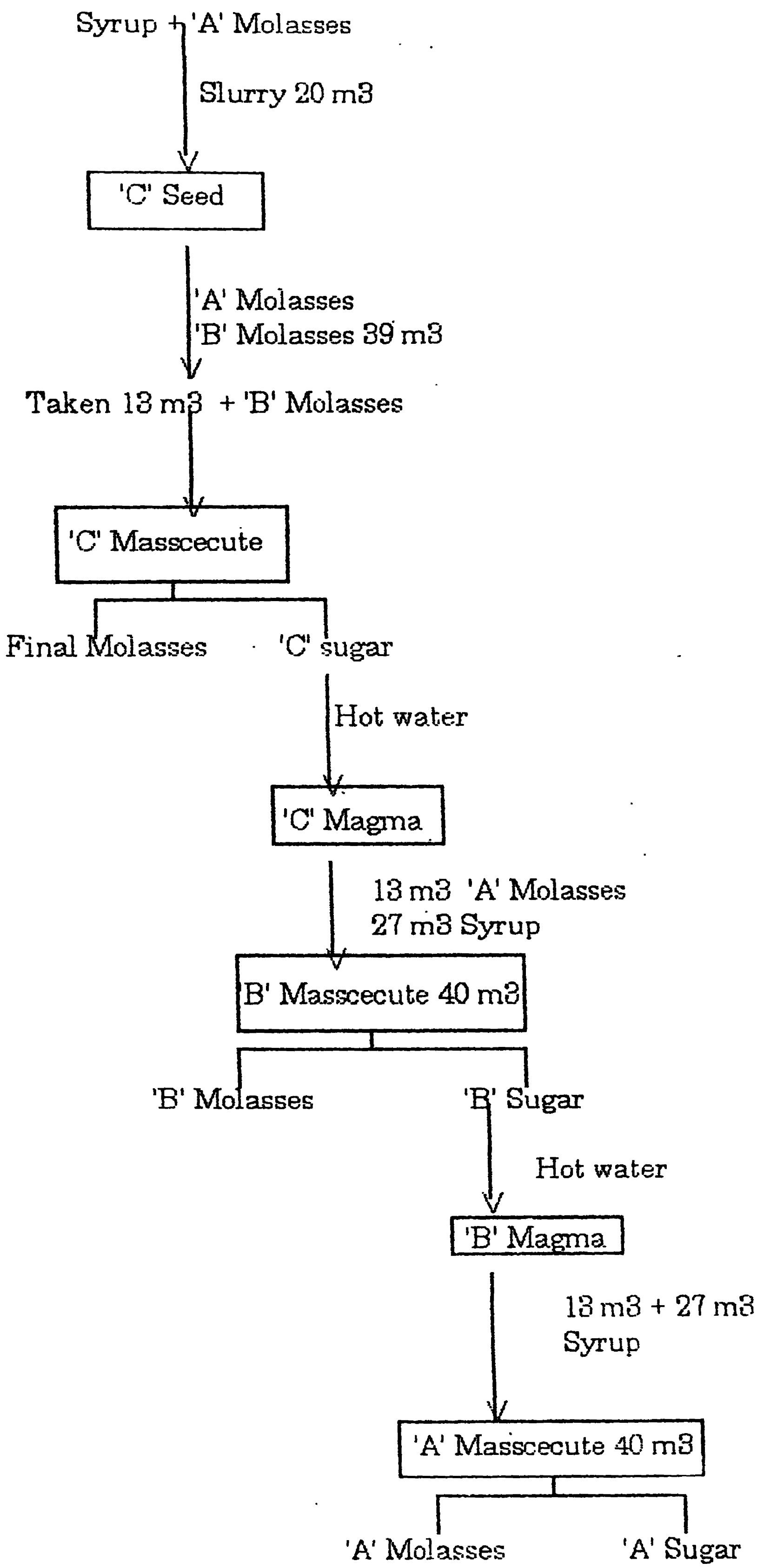
Figure 3.5 Bagging of sugar.

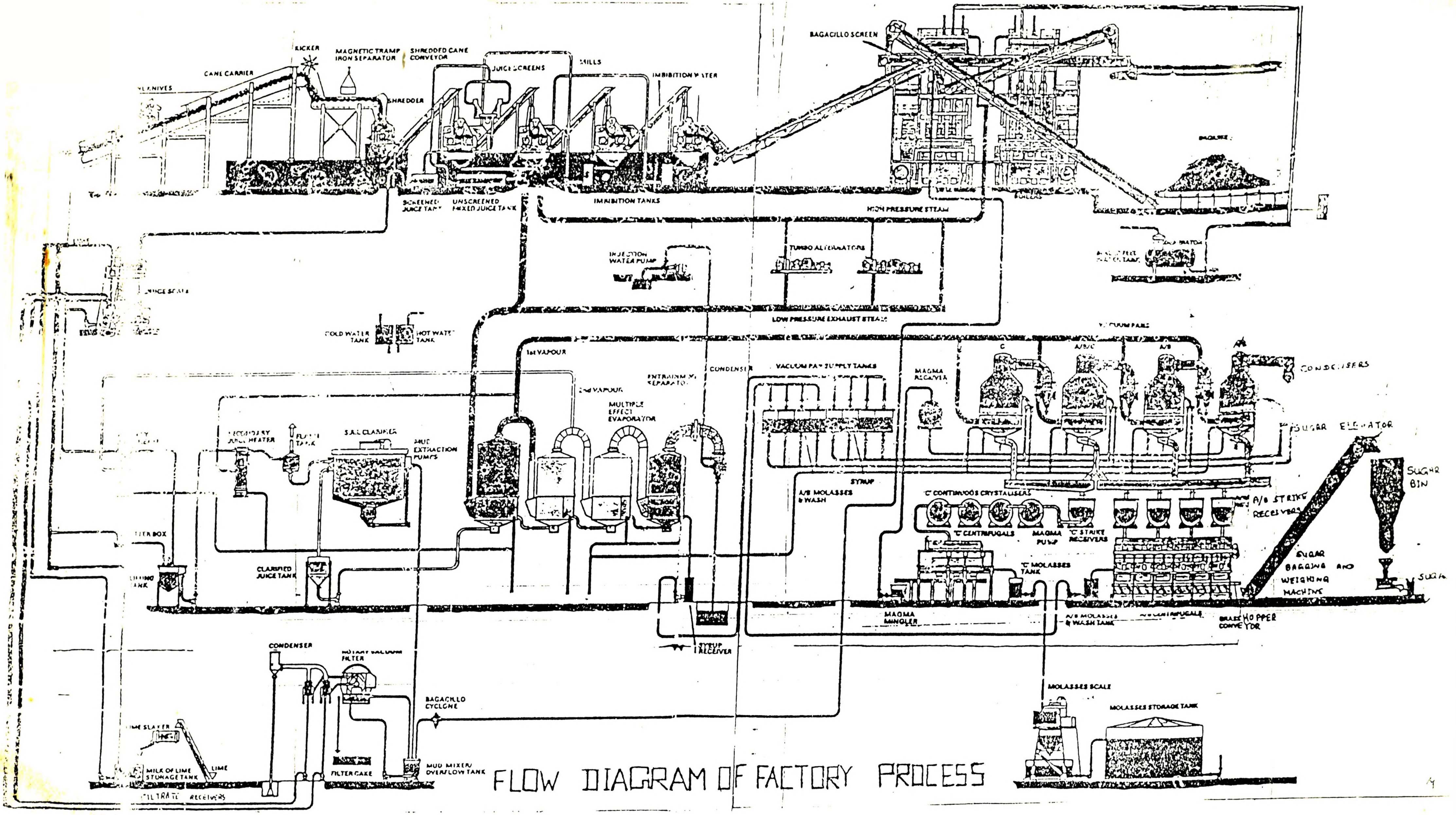
3.2.3 The capacity of the factory at PSC

1. Highest tonnage of cane milled per day is 4142 mt (24/08/93)
2. Highest tonnage of cane milled per week is 23476 mt

3. Weekly sugar made and estimated 2121.13 mt
4. Highest sugar bagged per week is 2107.05 mt
5. Highest amount of sugar bagged per day is 391.55 (25/08/93)
6. Highest annual production of sugar is 47612 mt.

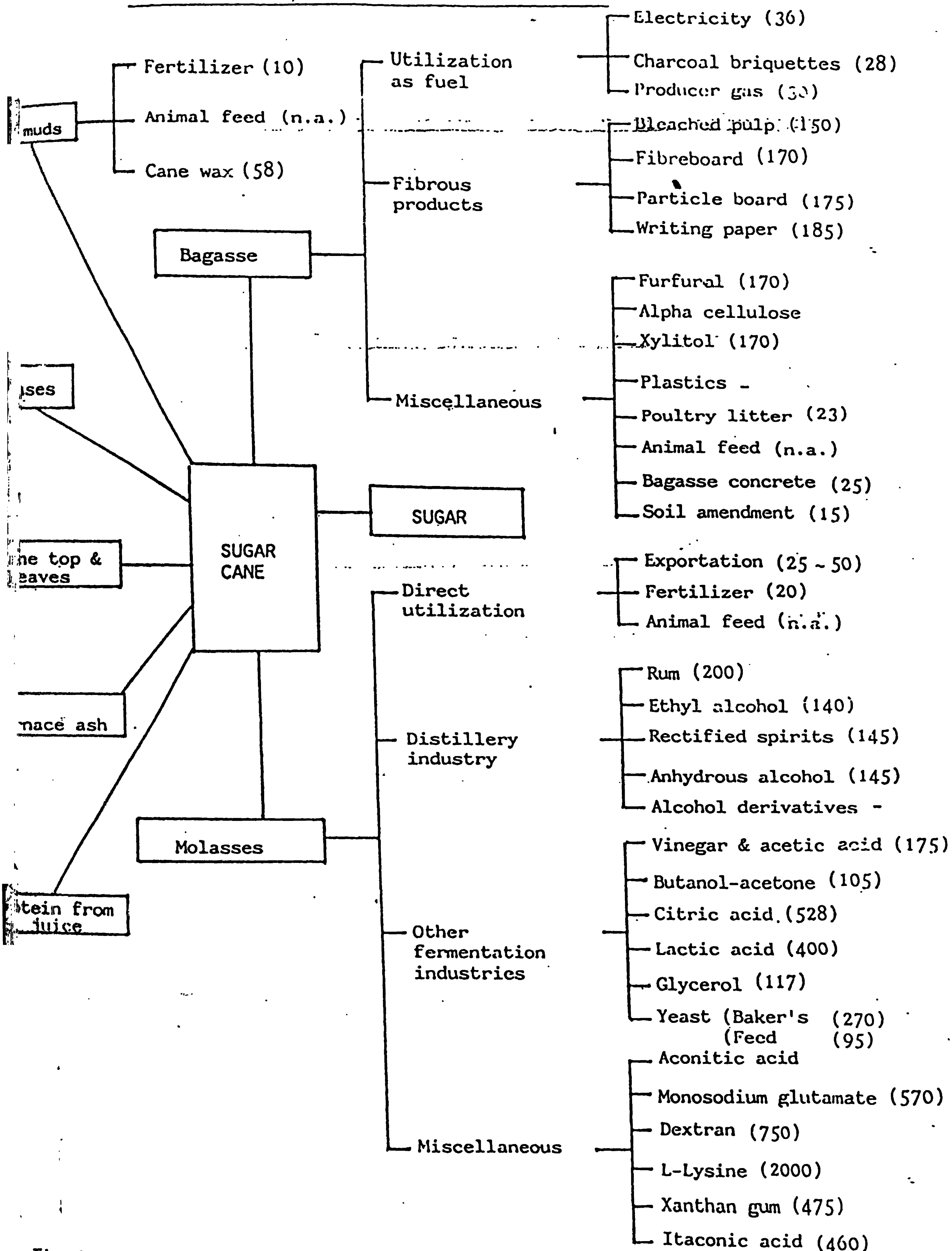
Figure 3.6 THE FLOW DIAGRAM OF PAN PROCESS





FLOW DIAGRAM OF FACTORY PROCESS

BY-PRODUCTS OF THE CANE SUGAR INDUSTRY



The figures following each product express the salable value in dollars of this product obtainable from one tonne of raw material.

3.3 Quality Management.

The Dextran affect on sugar quality.

The Dextran.

When the harvested cane is left in the field for more than 24 hours, there are possibilities to face tremendous effects on cane the quality of cane juice and its sequences of processing.

Normally the cane field is burnt before harvesting to facilitate the harvesting activities. But, on the other hand, harmful effects are also taken place on the quality of juice.

When the cane is burnt, normally the wax layer around the stem is completely removed.There is a formation of cracks on the stem due to the removal of this wax coat.Therefore, the certain kind of dangerous micro- organisms enter into the stalk through the cracks and both cut ends.

The micro-organism

which is called Leuconostoc mesenteritis (bacteria) enters into the stalk and causes very adverse effect on the juice of cane.

Normally the juice of cane contains higher percentage of sucrose than any other sugars and this sucrose is converted into glucose and fructose by the activity of the above bacteria and by the continuous respiration process that takes place even after harvesting process.

Therefore, the quantity of sucrose is reduced whilst the quantity of glucose and fructose increased and become useless for making sugar.

The glucose and fructose jones several times together and form a polymerized like compound which is called Dextran

This Dextran is also one kind of sugar and consists of, many linkages between the molecules and it is a polymerized compound due to the higher linkages.The Dextran is a very high viscosity one and this is the compound which performs a great challenge on sugar production.

**** The adverse effect of Dextran on sugar processing.**

1. It takes more time for getting proper boiling stage.
2. Crushing capacity is reduced resulting delay in the pan stage.
3. There is a certain size of crystals for the sugar. but the size of crystal is elongated by the dextran.
4. It is clogged up the centrifugal screens.
5. Losses of high percentage of molasses.
6. The quality of sugar is reduced.

**** The prevention of Dextran**

The special characteristic feature of this dextran is, it has a ability to multiply with increasing number like 2, 4, 16, 32........ Because of this multiple character, no any control measures have been found out except the application of dextranase enzyme. The enzyme only dextranase has an ability to reduce the multiple characteristic feature of this dextran. In Pelwatte, no application of this dextranase is done due to high price and it is used in the foreign countries to produce good quality of sugar.

Experiment No. 01.

Determining the quantity 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 under control of this dextran.

Materials and chemicals:-

* stand	* burette
* pipette	* conical flask
* volumetric flask	* beaker
* measuring cylinder	* buckner funnel
* 420-890 mm filter paper	* filter paper(No, 5)
* stop watch	* thermometer
* suction pump	* comparator
* spectrophotometer	* electronic balance
* table XV continued	* glass rods
* Mixed resin	* trichloro acetic acid
* kieselguhr	* alcohol (98 %)

Procedures:-

* The mixed juice is collected continuously for 8 hours to make it possible practically. The mixed juice was stirred well and filtered to remove the bagassilo.

* Then 60.00 ml of this filtered sample was measured with a measuring cylinder and poured it into the conical flask.

* Thereafter, 2.00 g of mixed resin was added and shaken continuously for 10 minutes.

* Once again the sample was filtered and 50.00 ml of this sample was taken into the conical flask.

* Then, 10.00 g of trichloro acetic acid powdered was dissolved in 100 ml of distilled water, and 10.[illegible] ml of dissolved trichloro acetic acid was added into the sample and mixed well.

* Then certain amount of kieselguhr was added and mixed well. This compound makes it easy for filtering.

* Then the sample was filtered by vacuum pump or suction pump

* After the vacuum filtration, the filtered sample was taken into two separate volumetric flask up to 12.50 ml volume

*** Then, absolute alcohol was pipette out and poured into one volumetric flask up to the mark of 25.00 ml.(12.50 ml of filtered sample +12.50 ml of alcohol).**

*** In the similar manner, distilled water was added into another volumetric flask up to the mark of 25.00 ml (12.50ml) of filtered sample + 12.50 ml of distilled water).**

*** The alcohol was added with continuous shaking and within a minute.**

*** Thereafter, these two samples were shaken well and kept at room temperature for 20 minutes.**

* Then these both mixtures were poured into two separate test tubes and the out side of the test tubes was washed off with distilled water.

* Then, these two tubes were put inside the shell and the colour difference of this two sample was observed.

* Finally, the wave length of the spectrophotometer was set up at 720 and the shell was put inside of the spectrophotometer.

* The Brix value of the mixed juice was obtained and the temperature of it was noted.

Calculation:-

The reading at wave length 720 was	= 0.156
The Brix value of mixed juice was	= 15.20
The Brix value from the table	= 16.112
Temperature	= 20^{0} C
Dextran value from XV graph	= 2.8

$$\text{The correct dextran value} = \frac{2.8 \times 60.00 \times 20.00}{12.5 \times 0.16112}$$

$$= 1680.00 \text{ ppm}$$

Discussion:- The harmless quantity of dextran is about 1500 ppm. If this figure rises up to the above level, the quality of sugar is affected adversely.

Experiment No. 02.

Determining the percentage of pol in final bagasse

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

Materials and chemicals.

* stop watch
* measuring cylinder
* thermometer
* filter paper
* standard pol table
* alcohol
* analytical balance
* conical flask
* disintegrator
* polariscope
* lead acetic acetate

Procedure:-

* First of all 500.00 g of final bagasse was weighed out and 5 liters of normal water was added to the bagasse and mixed well.
* Then this mixture was transferred into the disintegrator and mixed well for 30 minutes.

* Thereafter. 200 ml of mixed sample was separated and filtered into filter paper.Thereafter filtering, 200 ml of sample was taken into the conical flask and a small amount of lead acetic acetate was added to clear the sample.
* Then the cleared sample was poured into 400 mm pol tube and put into the polariscope and the final reading was obtained.
* Finally, the pol percentage was found out from the standard table.

or,

The percentage of pol in bagasse was found out by the following calculation;

$$\text{The pol percentage in bagasse} = \frac{R \times 0.26\,(1000 + W)}{200 - 26R/Q}$$

Where, W = moisture percentage of bagasse

Q = purity of residual juice

R = pol reading of extract

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

Experiment No. 03

Determining the percentage of pol in final molasses.

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

Materials and chemicals.

* analytical balance
* thermometer
* pipette
* polariscope
* lead acetic acid
* conical flask
* filter paper
* measuring cylinder
* distilled water

Procedure:-

* first of all,50.00 g of final molasses and 50.00 g of distilled water were weighed out and then mixed well together.
* Then, 78.00 g of mixed sample was weighed out and 500 ml of distilled water was added into the sample and mixed well.
* After that 11 or 11.5 g of lead acetic acid was added and filtered into filter paper.
* Then 50.00 ml of filter sample was taken 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 55.00 ml
* Finally the sample was poured into 200 mm pol tube and observed the reading in polariscope.

Calculation:-

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

Discuussion:- 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.

Experiment No. 04

Determining the total dissolved solids. (T.D.S)

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

Materials and chemicals,

* beaker
* pipette
* conical flask
* filter paper
* glass rods
* thermometer
* polariscope
* distilled water

* phenopthaline
* acetic acid
* conductor meter

Procedure:-

* Firstly, 100 ml of sample was taken into the beaker and added 2-3 drops of phenopthaline an mixed well.The colour of it is purple
* After that, a certain amount of acetic acid was added until the purple colour was disappeared completely. The temperature was measured and finally, the conductivity was measured with conductor meter.

Calculation:-

$$\text{Total Dissolved Solid (T.D.S)} = \frac{\text{conductivity reading X 0.7}}{1 - 0.002\,(20 - t)}$$

Where; t = 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.

Experiment No. 05.

Determining the percentage of pol in filter mud.

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

Materials and chemicals:

* analytical balance
* beaker
* pipette
* filter paper
* lead acetic acid
* thermometer
* conical flask
* polariscope
* distilled water

Procedure:-

* First of all, 50.00 g of filter mud was weighed out and the distilled water was added with filter mud making the total volume of 200 ml.

* Then, a little amount of lead acetic acid was added and mixed well.After it was filtered into the filter paper, and the filtered sample must be yellow in colour.

* Then the sample was poured into the 200 ml pol tube and put into the polariscope and the reading was obtained

Discssion:- The average pol percent in the filter mud is between 1.5-2 . The recovery of sugar would be low, when this figure passes this above level.

Experiment No. 06

Determining the hydrazine amount in boiling water.

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

Materials and chemicals:-

* pipette
* thermo metre
* test tube
* filter paper
* beaker
* comparator
* hydrazine

Procedure

* First of all, turbid sample must be filtered into filter paper.

* then 5 ml of water sample was taken into the test tube and similarly the same amount of hydrazone was taken into another test tube.

* then these two samples were mixed together (10 ml) and after that 10 ml of distilled water was taken into another test tube.

* after 2 minutes, those two tubes were kept in the comparator and noted the difference of the colour.

Discussion:- The normal availability of oxgygen in the boiling water is about 0.2. The possibility of corrosion in the pans would be high when this figure increases.

Experiment No. 07

Determining the sugar trace (sucrose content)

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

Materials and Chemicals:-

* test tube	* con. H_2SO_4
* alpha napthole	* glass rod

Procedure.

* Firstly, 5 ml of sample was taken into the test tube.

* Thereafter, 4 - 5 drops of alpha napthole was added and after that, 5 ml of Con. H_2SO_4 was added little by little at along the walls of the tube.

* if sucrose present, the violet ring is formed. If not, no formation of violet ring is observed

Discussion:- The boilng water should be tested as soon as possible to minimize the quantity of sucrose and to increase the sugar recovery.

Experiment No. 08

Determining brix value by hand refractometer

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

Materials and chemicals:-

* hand refractor meter	* blotting paper
* distilled water	

Procedure

* the glass plate of the refractometer was washed off with distilled water and wiped out with blotting paper.

* the 2 - 3 drops juice of cane was kept on the glass plate and the cover button was pressed.

* Finally the reading was obtained from the metre. it was considered to be correct Brix value of the juice of cane

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

Experiment No. 09

Determining the Brix value by Abbey refractometer

Purpose: **This experiment was done to measure the Brix value in the juice.**

Materials and chemicals:-

* test tube
* beaker
* blotting paper
* thermometer
* Brix value standard table
* distilled water

Procedure

* The glass plate of the metre was washed off with distilled water and wiped out with blotting paper then the reading was brought to neutral position.

* thereafter, a few drops of juice sample was kept on the glass plate and taken the incorrect Brix value.

* the temperature of the location was also noted.

* finally, the correct Brix value was calculated from the Brix value standard table.

Experiment No. 10

Determining the pol value by using polariscope

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

Materials and chemicals:-

* beaker
* polariscope
* test tube
* pol value standard table

* distilled water * blotting paper

* pol tube

Procedure

* First of all 100 ml of sample was taken into the beaker and about 1 g of lead acetic acid was added and mixed well.

* then it was filtered into filter paper and after that, the filtered sample was poured into 200 ml pol tube and put into the polariscope.

* Finally the correct pol value was obtained from the standard table.

Experiment No. 11

Determining the moisture percent in final bagasse (oven method)

Purpose:- This experiment was done to measure the percentage of moisture in final bagasse and take actions to control it.

Materials and chemicals:-

* stop watch * analytical balance

* oven * tray

Procedure

* After the drying the tray, it was weighed out.

* Then 100.00 g of bagasse was weighed out and kept in the tray.

* After that, the sample with tray was dried at 105°C with an electric oven for 3 hours until it gets constant weight.

* the tray was removed from the oven after 3 hours.

Calculation

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

CHAPTER 1V

RECOMMENDATIONS

The quality and quantity of sugar production mainly depend on the quality of juice of cane.The affects of pests and diseases also severely reduce the quality of juice.Therefore, the varieties which performs for the pest and disease attack should be planted to produce successful yield.

A higher quantity of juice is thrown out each and every day from both agronomic section and the laboratory experimental period. Instead of wasting them, this juice can be sent to the processing stage in the factory by means of conveyer systems.

The composed fertilizer can be made by using bagasse, filter mud and filter cake for the commercial purposes.

All the steps should be taken to remove the cane from the field as soon as possible after harvesting .

Care should be taken to shorten the transport distance and to minimize the physical and mechanical damages during loading and transportation.

REFERENCES

Agnihotri, V.P., 1990, Diseases of sugar cane and sugar beet.Revised edition. Sunil printers, New Delhi. pp.23-25, 73-75, 213-214, 237-238.

Babu, C.N., 1990.Sugar cane. Second edition. Ravi S achdev, New Delhi. pp. 55-78.

Balasuriya, A., Pest. Unit, 4.8 .Document from Pelwatte Sugar Industry.

Balasuriya, A.,Disease.Unit, 4.10, Document from Pelwatte Sugar Industries.

Bakker, H., Sugar crop. Unit, 1.3, Document from Pelwatte Sugar Industries.

Harris, W.V., Termites as pest of sugar cane. Termites research unit, British museum, London. Document from Pelwatte sugar industry.

Johnson, E..D., Sugar factory. Unit, 1.4, Document from Pelwatte sugar industry. p.1-5.

Mathur, R.B.L., 1993. Hand book of cane sugar technology.Second edition. Oxford and IBH Co, New Delhi.pp. 12-15.

Mattananda, C., 1990.Sugar cane growing in Sri Lanka. pp.1-5 , m130-150.

Wendt, W.B., Cane ripening.Unit, 4.14, Document from Pelwatte sugar industry. p.1-6.

National Digitization Project

National Science Foundation

Institute : Sabaragamuwa University of Sri Lanka

1. Place of Scanning : Sabaragamuwa University of Sri Lanka, Belihuloya
2. Date Scanned : 2017-09-19
3. Name of Digitizing Company : Sanje (Private) Ltd, No 435/16, Kottawa Rd, Hokandara North, Arangala, Hokandara
4. Scanning Officer

Name : S.A.C. Sandaruwan

Signature : ....

Certification of Scanning

I hereby certify that the scanning of this document was carried out under my supervision, according to the norms and standards of digital scanning accurately, also keeping with the originality of the original document to be accepted in a court of law.

Certifying Officer

Designation : Librarian.

Name : T. N. Neighsoorei.

Signature : ....

Date : 2017-09-19

"This document/publication was digitized under National Digitization Project of the National Science Foundation, Sri Lanka"