DESIGN OF SPIRNKLER IRRIGATION SYSTEM FOR W24 EXTENSION FIELD BLOCK OF NIGERIAN SUGAR COMPANY, PLANTATION BACITA, KWARA STATE.

BY

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DEDICATION

This project is dedicated to the God almighty and my family Mr. and Mrs Joshua Saidu and Master Mathias J. Saidu

CERTIFICATION

This is to certify that this work was carried out by Saidu, Joshua in the department of Agricultural Engineering, Federal University of Tecnology, Minna.

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TABLE OF CONTENT

CHAPTER III

CHAPTER IV

LIST OF TABLES

TABLES

Pages

LIST OF FIGURES

ABSTRACT

The decline in Sugar Cane Production in the company has informed the design of Sprinkler Irrigation System for W23/24 Extension field block of the Estate Plantation, in Edu Local Government Area of Kwara State.

A total area of 50 hectares was surveyed for this project. The soil of this area is mostly clay loam in West Management Area of the of the sugar plantation. The topography of the land is fairly plain and the main source of irrigation water is from River Niger Via Niger-Yelwa loop.

The design of this project as rightly said came to being as a result of low yield of sugar cane from the existing fields of the plantation.

Achieving required sugar cane yield from the plantation is nothing but, to extend or develop more fields to substitute the exhausted ones so as to enable the company to meet up with the targeted sugar cane production.

From the result of cost benefit analysis for this project, the cost benefit ratio is 1:3 which indicates that the project is feasible and economically viable.

CHAPTER ONE

1.0 INTRODUCTION

The Nigerian Sugar Company Limited (NISUCO) Bacita is the nation's Premier and Foremost Sugar Manufacturere, was established after a three – years trials at a location which satisfied the requirement of Large-Scale Commercial Sugar Production Viz: fertile land for sustainable sugar production, adequate and secured water supply for irrigation, favourable climatic and edaphic conditions and accessibility of road and railway transport nereby. The company, since its inception in 1961 and Pioneer Production in 1964, has been a successful private sector – led enterprise in Nigeria as it has been able to harness to human and material resources to meet its designed capacity.

However, it would be revealed from the Bacita enterprise that successful investment in sugar production and its sustainability, all other factors being equal, is precedent on huge capital investment and sustainability in the provision of reliable water supply to meet the irrigation requirements of sugar cane as well as provide adequate drainage facilities and control structures to remove excess water from the plantation among others.

The company is managed and operated by Nigerians. The Sugar Cane Plantation has been under irrigation system since 1964. The systems of irrigation in operation in the plantation are surface (gravity) and Sprinkler (overhead) irrigation. The methods being practiced and have been successful as far as the field of sugar cane from the plantation is concerned.

1.1 OBJECTIVES

1. The main purpose of this project is to put part of the virgin land of the sugar cane plantation under the design of sprinkler irrigation system. Other requirement to be determined include the amount and quality of water to be provided to the farm through the sprinkler irrigation system.
2. The crop (sugar cane) water requirement and its relation to cane yield shall be discussed based on the available data collected from tests and experiments carried out by the irrigation section and field technology laboratory of Nigerian Sugar Company Bacita, such data includes meteorological data, soil test results and soil survey results.
3. The most suitable water management methods adopted in the sugar plantation, such as water distribution, water conveyance, water application, crop water use and field water use efficiencies are also very important in this project work.
4. The cost of Practicing Sprinkler Irrigation System shall also be determined for future expansion of sugar cane plantation in Nigerian Sugar Company, Bacita, Kwara State.

.2 LOCATION

Bacita Sugar Estate is located on the South Bank of River Niger in Edu Local Government Area (LGA) of Kwara State. It is in Tsaragi District at Latitude 09'N and Longitude 05'E and lies in the the Guinea Savannah Region at altitude of 76 metres above sea level. Bacita is 120KM North of the state capital, Ilorin, and almost equidistant (420km) between Lagos and the new Federal Capital Territory, Abuja. The Estate is located on the River Niger flood plain and the topography is that undulating micro-topography and some poorly drained depressions.

1.3 CLIMATIC CONDITION

The Climatic data given on Tables 1.1,1.2,1.3, 1.4, 1.5, 1.6 and 1.7 as attached are obtained from the field laboratory technology unit of Nigerian Sugar Company, Bacita. The tables attached gives the ten year (1991-2000) monthly mean maximum temperature of 33-8^{o}c (from table 1.1). While the monthly mean minimum air temperature is 21.8^{0}c (from table 1.2).

Also ten years recorded monthly relative humidity, wind speed, sun-shine hours, and evaporation are as given in the tables 1.4, 1.5, 1.6 and 1.7.

1.3.1 RAINFALL

The period of rainfall in Bacita, generally is between the month of April or May to October. The peak rainfall normally occurs around the month of August and September every year. The rainfall at Bacita varies considerably from year to year as can be seen from table 1.3 showing ten years annual average rainfall of 93.5mm.

The effective rainfall which is the portion of rain assumed to be utilized in meeting the evapotranspiration requirement of the crop is worked out from the assumed relationship between actual rainfall and effective rainfall (that rainfall less than 1mm).

1.2.1 WIND

Wind velocity is also an important factor which needs to be considered in the process of designing both Surface and Sprinkler Irrigation Methods, as it has effects on the rate of evaporation from the soil and also the uniformity of water application through Sprinkler nozzle.

The project area is affected by two major wind currents, that is North – East and South-West-Wind. North-East-Wind that brings about dry winds (Hamattan) from Sahara desert, experienced from the month of November to March every year and the South-West that brings about rainy season begins in the later part of April or May each year.

The mean yearly wind speed, as calculated from the Nigerian Sugar Company, Bacita, over the past ten years was 72.63 kilometer per hour. The wind speed are characteristically lower in the month of September, October and greater in the month of November to March.

1.3.3 SUN-SHINE

The sun-shine in the area is always very high during the month of December through March. This is critical period when crops demands a lot of water from irrigation.

Sun radiation for the period of ten years was recorded in table

1.7 with the years average sun-shine of 5.15 hours.

1.4.0 TOPOGRAPHY

The topography is that undulating micro-topography and some poorly drained depressions which permits the practice of both surface and Sprinkler Methods of Irrigation. The project area is relatively flat with gentle slope in some places and having an average slope grade between 0.5% to 1% in the direction of low spots within the field. The soil of this area is mostly clay loam.

1.4.1 DRAINAGE

Removal of excess water is another critical factor in ensuring high sugar cane yields. Ponding, flooding etc of cane fields induce anaerobic conditions in the soil, and reduces root efficiency in respect of nutrient and water uptake, and consequently low cane yield. It is therefore very important to have good drainage operations in the cane plantation.

1.5 SOURCE OF WATER IN THE AREA

The main source of water supply in NISUCO cane fields is via an abstraction from a loop from River Niger (called Yelwa Loop), at an elevation 72 meters and Gravitational flow into a 5.5km Main Niger Canal (MNC). Water is then elevated into a basin through three giant pumps in the Niger Pump House (NPH) and thereafter distributed to the estate plantation via an array of secondary and tertiary canals.

Other supplementary sources of water to the plantation are Oshin River from upstream Ilorin down to the area, via the construction of yearly earth dam called Oshin reservoir and Ndafa stream which also urguement the supply through a weir constructed across the river to supply water to sugar cane plantation.

1.5.1 QUANTITY OF WATER

There is always over 4,245,000m3 of water from River Niger during rainy season, through the natural course by gravity flow into Niger pump house intake channel. The volume of water reduces to about 3,830,000m3 as from the month of February to April every year. Usually, this is the period that the plantation experiences acute water supply for irrigation.

1.5.2 QUALITY OF WATER

The qualitative analysis of the water is carried out by the field laboratory section of the company and gave the following results, salt less than 700ppm, sodium concentration less than 60% of total salts, Boron concentration below 0.5ppm.

1.6 THE TOWNSHIP

Bacita township is in Tsaragi district of Edu Local Government Area of Kwara State, with population of about thirty nine thousand people. The language of the inhabitants are, the Nupes, which are the dominate tribe, other tribe like the Yorubas, Tiv, Hausa, Idoma and Igbo are also there working under the company.

1.6.1 OCCUPATION

The main occupation of the people in this environ where the project is sited is farming, fishing and petty trading.

1.6.2 LAND TENURE SYSTEM

The land tenure system of Bacita and its surrounding areas is of communal type in which the land belongs to the community and put under the control of the community leader who can allocates the land to individual and government on request.

1.7.0 REASONS FOR SETTING THE PROJECT/JUSTIFICATION

To improve and increase the cane and sugar tonnage in Nigerian Sugar Company for the benefit of the country.

To provide employment for the able men and women through out Nigeria and it environs.

To provide domestic supply of refined sugar

To save foreign exchange or increased foreign earning for the country.

To provide technical and agricultural education to the local people.

CHAPTER TWO

2.0 LITERATURE REVIEW

The Nigerian Sugar Company has been under irrigation since 1964 after its establishment in 1957. The projected production from the Estate was to be 50,000 metric tones of refined granulated sugar per year at full production capacity. In 1984 with 55% of cultivated area of 5600 ha under production, the estate has produced an annual maximum of 30,000 tones of sugar. This production was only about 5% of sugar needs of the country, Nigeria. In 1982 Nigeria imported 900,000 tones of sugar expending about N200 million of the country's foreign reserves for the purpose (Kaloma 1982).

According to Doorenbus et al (1979), sugar cane is a tropical crop which is grown predominantly between latitude 30^0 N and 30^0s. The suitable temperature range is between 18^0c and 30^0c. In most of the growing areas, crop production is often restricted by limited seasonal rainfall. Sugar cane required between 1500mm to 2500mm of water per year depending on the climate. Bacita has an annual average rainfall of 1036mm against an annual average crop water requirement of 1610mm for sugar cane. Therefore, the crop requires supplementary water through irrigation especially during the dry month of October to May which is the annually critical period of water needs for sugar cane growth.

DEFINITION OF IRRIGATION

Irrigation is generally defined as the artificial application of water to the land for the purpose of promoting or maintaining crop growth. It can also be convinced as all measures by which water supply to the soil for crop growth is provided artificially. The application of irrigation comes into consideration when the natural precipitation (rainfall) in an area is not enough to support crops growth or when the absence of natural rainfall is ruled. In the former case irrigation is only supplement to the natural rains and hence is called supplementary irrigation. In the later case crop growth is impossible without irrigation.

2.1 HISTORY OF SUGAR CANE IRRIGATION

Sugar cane irrigation is a world-wide arts which has been put into practice for quite (centuries) in the different countries of the world. Many countries of the world have been benefiting from sugar cane irrigation practices, such as Egypt which use Nile Valley to irrigate their desert land for sugar cane production for many years up till today. Some countries that practice sugar cane irrigation includes, India, Brazil, Guyana, the West Indias and Cuba. African countries that also practices sugar cane irrigation production includes, Kenya, Nigeria, South Africa, Sudan, Uganda, Egypt, Ethiopia, Zaire, Mauritius, Angola, Mozambique, among others.

2.3 SUGAR CANE IRRIGATION REQUIREMENT

The sugar cane irrigation requirement is that portion of the consumptive use which must be supplied by irrigation. It is the consumptive use less the effective precipitation. The winter precipitation is also effective only to the extent that it remains in the soil until the growing season for plants. The effective growing season precipitation is the sum of the monthly values of effective precipitation. The average annual effective precipitation for the period of record is subtracted from the estimated annual consumptive use to determine the annual crop irrigation requirement.

2.4 SUGAR CANE PRODUCTION AND WATER SECURITY

Sugar cane (saccarium offinaciarium) is an annual crop whose cultivation and yield are highly correlated with water availability and security. It's agronomic activities – planting, germination, crop establishment, nutrient uptake, herbicide and fertilizer application, crop maturity and ripening (Leading to Sucrose Sugar Accumulation) – are all tied to efficient water resource utilization and management.

Unavailability or inadequate supply of water, more than any other factor accounts for low yields in as much as excess water arising from flooding.

Excess water reduce air supply to the root and result in stunted growth as well as irreversible conversion of sucrose (sugar) in the plant into other forms of carbohydrates from which sugar cannot be economically processed in the factory.

2.5.0 IRRIGATION METHODS PRACTICED IN THE SUGAR PLANTATION

The methods of irrigation presently in practice at Nigerian Sugar Company plantation are Furrow (Surface) irrigation and Sprinkler (overhead) irrigation system.

2.5.1 FURROW IRRIGATION SYSTEM

In the furrow irrigation method, water is conveyed between two ridges which are closely spaced. Water is supplied to the furrow from the head ditch while a tail ditch collects the run off water and usually is circulated for re-use. After the water has been pumped to the furrows, the irrigators who works on shift basis then irrigates the sugar cane with the help of local hoes by opening the small bunds that is usually constructed across the furrows, whereby the water moves into the furrows which irrigate the crop.

The general slope grade is between 0-5% and the length of the furrow depends on a particular surface water hydraulies. The spacing of the furrows is from 0.5m-1.5m in good soil of good permeability. In some cases, it may be up to 2-3m apart. It is designed to apply a net irrigation water of 75mm in 14 days fixed cycle.

2.5.2 SPRINKLER IRRIGATION SYSTEM

This is the method of irrigation where water is applied to crops in the form of rain or by spraying water in the air. This method involves the use of pressure pumps, pipes and sprinklers which are designed for irrigating the sugar cane. It is a widely used system because it has no limitation to choice of soil or to the topography of the area. In this method waste of water due to run off is not practicable. The efficiency of application is almost 100%. The initial cost is high but the system is highly profitable in the long term since production is high and labour cost minimised.

The Sprinkler system was designed to apply net irrigation water of 60mm in 9 days fixed cycle. The system is popularly referred to as overhead irrigation at Bacita Sugar Cane Plantation. This system of irrigation in Bacita Sugar Company, covers the following management areas, Oshin/Yelwa, Belle, East and West/Ndafa management areas.

2.6.0 OTHER METHODS OF IRRIGATION NOT IN PRACTICE AT BACITA SUGAR PLANTATION.

2.6.1 SUB IRRIGATION

This is generally the application of water below the soil surface. The required conditions for this method of irrigation are permeable soil in the root zone, under lain an impermeable layer or a high water table. Water is delivered to the field in ditches spaced 15m to 30m apart and is allowed to seep into the ground to maintain the water table at a height such that water from the capillary fringe is available to the crops. Low flow rates are necessary in the supply ditches and free drainage of water must be permitted, either naturally or with drainage work to prevent water logging of the field.

Sub irrigation results in a minimum of evaporation loss and surface waste and requires little field preparation and labour. Michael (622).

2.6.2 DRIP IRRIGATION

In this method a perforated plastic pipe is laid along the ground at the base of row of plants. The perforations are designed to emit a trickle (5 litres/hr or less) and spaced to produce a wetted strip along the crop row or wetted bulb at each plant. The main advantage of trickle irrigation is the excellent control, since water can be applied at a rate close to the rate of consumption by the plant. Michael (663).

Evaporation from the soil surface is minimal and deep percolation almost entirely avoided. Nutrients can be applied directly to the plant roots by adding liquid fertilizer to the water.

2.6.3 BASIN IRRIGATION

A basin is regarded as a flat piece of land surrounded by checks. Basin irrigation, therefore involves level areas pounded by the check or dykes. It is usually adopted for irrigating orchards and some cases field crop such as maize, sorghum and wheat. A basin may be made for one tree or two to five trees or more. Michael (603)

The water usually gets to basin from the supply ditch in which case each basin gets its supply directly from a ditch. Another method allows the water to flow from one basin to another.

2.6.4 BOARDER STRIP IRRIGATION

This method of irrigation is usually practiced on slope greater than 0.1% or up to 3%. It can also be used on slope of up to 7%. This method is suitable for close grain crops such as beans, maize and sorghum. Michael (585)

It is suitable for soil of medium into wider stream up to 20m and 100 to 400m long. A long the direction of the predominant slope. The strips are separated by low earth levees or checks. It is necessary for good water application, that is the land carefully graded to remove minor undulation.

2.7 ECONOMICS OF IRRIGATION

Economics is important in evaluation practices because irrigation is for the purpose of increasing profit. Higher profit as a result of more efficient production of sugar will result to lower prices for consumers and this means more consumption of sugar and other food crops which will raise the high standard of living for the whole people of the country Nigeria. Irrigation projects and other agricultural works aims at making the world a better place to live. Michael (279).

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 EXPERIMENTAL INVESTIGATION

Before embarking on any irrigation project an investigation have to be carried out to establish the viability of the project. The following investigations were carried out for the planning and maintenance of the project.

3.2 RECONNAISANCE SURVEY

This is the first preliminary survey which is normally carried out on a field, it involves going round the field to be surveyed and demarcating the common areas of the project site.

In the course of this preliminary survey both the general topography and the physical appearance of the surface of the soil were identified. It also give the idea of how the land will be drained or how pipes should be laid when sprinkler system is to be set on the land. After that the sketch of the area is produced and it is marked out by boundaries. The distances are then measured before the measurement of the actual project work.

3.3 DETAIL SURVEY

This was carried out by means of survey instrument (ranging poles, level, staff and pegs) used to determine the ground deviations. The base line was first established within the selected area which is 315 meters and it runs parallel to the main road leading to Belle, Yelwa and Fanagun Villages. The grid points was then established and pegged along the base line at an interval of 30 meters. The perpendicular lines was marked with grid points at an interval of 30 meters thus give a grid of 30x30 meters at equal interval.

.3.1 CONTOUR PLOTTING

This was carried out with the help of the reduced field elevation of the detail surveyed. It was carried out using graph papers marking each grids point on it with a representative scale (ie 1:10). The elevation of each grid point is written against its representing point. A contour of equal interval was run at an interval of 0.2 meters between each contour and that covers all the area which gives a proper topographic feature of the field.

.3.2 SOIL SAMPLING

The soil survey and map are very useful and necessary in any type of engineering field. The soil survey of the area was carried out and samples was collected for both physical and chemical analysis. Soil profile pits was dug at various points in the project area of the sugar plantation and samples collected from each horizon was identified in the laboratory of the company.

3.4 SOIL MECHANICAL ANALYSIS

The following procedures are used for the analysis:-

1. Take the soil sample and weight 50 grammes air dry soil into a beaker.
2. Add $50cm^3$ of 5% sodium Hexometalphosphate Solution.
3. Add 200cm3 destilled water or tap water
4. Allow it to settle for 30 minutes
5. Stir the soil suspension for 10-15 minutes with stirrer machine
6. Transfer it to a plastic or glass cylinder of (100cm3)
7. Insert the soil hydrometer and move it up until the hydrometer is suspended
8. Invert the cylinder to mix one or two times taking care not to break the hydrometer.
9. Take the temperature T_1 and note the hydrometer reading H_1 after 40 seconds. Convert the hydrometer reading if necessary.

10. Allow the hydrometer to remain in the suspension and after 2 hours read off the hydrometer H_2 and temperature T_2.

From the experiment conducted at the project site, the following data is obtained for determining the soil type of the project area.

1. Soil sample taken is 50g of sand

2. At 40 second readings:-

Hydrometer reading, $H_1 = 31$

Temperature reading, $T_1 = 26^0{}_c$

3. At 2 hours readings:-

Hydrometer reading, $H_2 = 16$

Temperature reading, $T_2 = 26^0{}_c$

Note that the hydrometer is calibrated at 20^0c, this means that the hydrometer gives accurate results only when the temperature is 20^0c. With any difference or variation in temperature above or below 20^0c a correction must be made.

Using bonyoucos hydrometer method for our calculation, C. F = Correction factor is 0.36 for every 1^0c above 20^0c.

CALCULATIONAt 40 seconds

$$\% \text{ Silt and clay} = \frac{H_1 + (\text{Temp.})}{50} \times \frac{100}{1}$$

Since the temperature reading from our experiment is 26^0c which is above the calibrated 20^0c we must make correction.

Therefore, temperature correction at 40 seconds is:-

$$6 \times (0.36) = 2.16$$

$$\% \text{ Silt and clay} = \frac{31 + 2.16}{50} \times \frac{100}{1}$$

$$= 66.3\% \text{ silt and clay.}$$

At 2 hours.

$$\% \text{ Clay} = \frac{H2 + (T2)}{50} \times \frac{100}{1}$$

$$= \frac{16 + 2.16}{50} \times \frac{100}{1}$$

$$= 36.3\% \text{ clay}$$

Therefore, 66.3% silt and clay minus 36% clay give % silt.

$$= 66.3 - 36.3$$

$$= 30\% \text{ silt.}$$

Finally, Percentage sand is,

= 100 - % silt and clay

= 100 – 66.3

= 33.7% sand.

Using the textural triangle with the above calculated percentages of clay, silt and sand, the soil textural class of the project area is CLAY LOAM.

3.4.1 DETERMINATION OF SOIL BULK DENSITY

The method used is to obtain an undisturbed soil sample of known volume. Core auger samples are used to take undisturbed soil samples. The cylinder of the core sample which has its cutting edge was driven into the soil and an undisturbed samples obtained within the table at various level as shown below. The samples are carefully trimmed at both ends of the core cylinder. They are dried in an oven at 105'c for about 24 hours until all the moisture is driven off and the sample weighed again. The volumes of the soil core is the same as the inside volume of the core cylinder. The weight of the soil in grams is divided by the volume of the soil core cc, is the bulk density for moist soils, it ranges from 10 gram/cc for clay to 1.8 gram/cc for sands. Bellow are some of the bulk density of some selected fields from the sugar plantation which covers both surface and sprinkler irrigation areas.

FIELD	AREA OF PLANTATION	AVERAGE BULK	SOIL MOISINOT AT
B1/B2	BELLE	1.01	16.71%
O1/)2	OSHIN	1.37	11.09%
W 23/24	WEST	1.70	10.12%
S1/2	SOUTH	1.15	27.43%
C6/7	CENTRAL	1.23	10.16%
E11/12	EAST	1.60	21.50%
N2/3	NORTH	1.29	11.06%

3.4.2 DETERMINATION OF SOIL STRUCTURE

This is simply the aggregation of primary soil particles (sand, silt and clay) into compound particles termed as peds or aggregates which are separated. In determining soil structure, it refers to the shape of the aggregates peds and it includes such forms as granular, crumb, blocky, platy or prismatic.

3.4.3 SOIL TYPE OF THE AREA

The nature of the surface soil in the whole project area is somewhat, clay loam underlaid by alluvial deposit. Generally the soil are well-drained, very pale brown, clay loam and has moderately medium, lain by dark brown, sandy clay loam. Followed is moderate medium platy structure with granular born clary.

3.5.0 DETERMINATION OF INFILTRATION RATE.

3.5.1. INFILTRATION

This is the movement of water from the ground surface into the soil. The soil infiltration test was carried out in the field for determination of the soil water intake rate at a given time so as to know the application depth and water movement of rate of soil. It was set at seven different points in the field to get a proper representation from the soil for the whole field. The infiltration consists of two deferent sizes of cylinder rings, that is the inner and the outer rings. The inner ring is 30cm diameter, while the outer ring is 60cm diameter. They are all placed into the soil together in one position by the use of heavy metal to drive them in the soil and wooden plant was placed on top of the ring to prevent damage to the edges of the metal rings. The smaller ring being placed in the larger ring 30cm apart. The water is ponded into the rings both inner and outer and graduated rule is placed about 3cm depth near the wall of the inner ring in the ponding water. The initial reading is taken from the graduated rule of inner ring and be recorded in data sheet. Then a continuos recording of movement of the water with an interval of 15,30,60,120,180,240 and 300 minutes is carried out.

Hence, infiltration rate for the whole field varies from point to point which depends on the nature and condition for the soil of that particular point, but all the way it appears to be the same as there is slight variation in the result. From the result it can be judged that the soil for the project area has an infiltration rate for the clay loam which was found to be 10.0mm/hour.

3.5.2 FACTORS AFFECTING INFILTRATION RATE AT SUGAR CANE PLANTATION

The infiltration rate of soil in the sugar cane plantation was observed to be affected by the following factors:- Initial moisture content, soil texture, porosity, hydraulic conductivity of soil profile, soil organic matter, vegetative cover, duration of irrigation, viscosity of water and condition of soil surface.

3.5.3 FIELD CAPACITY DETERMINATION

Field capacity is the amount of water left in the soil after the gravitational water has drained, say, one to three days after irrigation or rainfall. It was determined by group metric method.

The sample was taken from undisturbed soil two days after irrigation at 15-30cm byauger hole and the sample put in a cylinder of known volume ie 7.5cm in diameter and 15cm deep. The weight of the core sampling cylinder with moist soil was 2.8kg and then oven dried for 24 hours at 105^0c.

The oven dry soil weight 2.60kg. The weight of the core sampling cylinder was 1.50kg.

Therefore, Weight of the moist soil = 2.80-1.50 = 1.30kg

Weight of oven dry soil = 2.60-1.50 = 1.10kg

Percentage moistare content = $\frac{1.30-1.10}{1.10}$ x 100 = 18.2%

Volume of Core Cylinder = $\underline{\text{II}d^2 \text{ H}}$ = $\underline{\text{II x}}\ (75)^2$ x 15 = 662.7cm

Apparent specific gravity = Weight of dry soil in grams

Volume of the Core sampler

= 1.10 x 1000 = 1.65 or 1.7

662.7

Moisture content by volume = Apparent specific gravity x moisture

content

= 1.7 x 18.2 = 30.94cm Per Meter depth of soil.

3.54 PERMANENT WILTING POINT.

This is the soil moisture at which plant can no longer obtain enough moisture to meet up transpiration requirement and remain wilt and if even water is added to the soil the plant will still remain dry. As a result of this, the plant will start showing the effect of soil moisture reduction by wilting when temperature is high and if there are some wind blow. The permanent wilting point for the area under study is found to be 9% for the sugar cane, (from irrigation department 1996).

3.5.4 AVAILABLE WATER

This is the water that is available in the soil for plant use. It is the difference between field capacity and permanent wilting point and is also referred to as readily available moisture. Available water in most cases is expressed as percentage water.

Therefore, available water = Field capacity – Permanent wilting point.

$$= 18.2\% - 9\%$$

$$= 9.2\% \text{ by weight}$$

$$= 9.2 \times 1.7 \text{ by volume}$$

$$= 15.64\text{cm}$$

3.5.6 CONSUMPTIVE USE

Consumptive use of water involves problems of water supply both surface and underground, as well as problems of management and economics of irrigation project. Consumptive use is the combined use for describing the process by which moisture from the soil surface is evaporated and at the same time process by which plant transpire water to the atmosphere. It is used in estimating irrigation requirement and planning irrigation system.

Blanning criddle (1950) observed that the amount of water consumptively used by crops during their growing seasons was closely converted with mean monthly temperature and day light hours.

$$U = KF$$

$$F = \frac{t \times p}{100}$$

$$U = \frac{ktp}{100}$$

Where, U = Consumptive use for crops mm/day

K = Consumptive use inefficient for growing period

T = Mean monthly temperature, ^oC or ^oF

F = Monthly consumptive use factor

P = Monthly day light hours expressed as percent of day light hour of the year.

Calculation of consumptive use of water for sugar cane at Bacita by using Blanning Criddle formula for both rainy season and irrigation season at latitude 9^o_N 5^o_E from table 1.80., The Peak Consumptive use from the table is 5.8mm/day.

3.6.0 IRRIGATION EFFICIENCY

This is the method by which the available water supply is being used effectively without too much waste. The method of irrigation efficiency use at the project site are:-

3.6.1 WATER CONVEYANCE EFFICIENCY

This term is used to measure the efficiency of water conveyance system related with canal net work, water courses and field channels. The water conveyance for sugar cane plantation starts from Pump House (PH). Through check Kokodo, branch to Belle Management area of the plantation and also through the South Channel to East (40) block field. It can be calculated as follows with the given formula.

$$E_c = \frac{Wt \times 100}{Wd}$$

Where, E_c = Water conveyance efficiency, percent.

Wt = Water delivered to the irrigated field.

Wd = Water diverted from the source.

For example

Wd = 120 cfs (0.02832 x120) = 3.3984m3/sec

Wt = 100 cfs (0.02832 x 100) = 2.832m3/sec

:- $$Ec = \frac{2.832 \times 100}{3.3984}$$

= 83.3%

3.6.2 WATER APPLICATION EFFICIENCY

This explain the way water supply to the field is used efficiently by the irrigation. It is expressed as follows:-

$$Ea = \frac{Ws}{W} \times 100$$

Where, Ea = Water application efficiency, percent

Ws = Water stored in the root zone of the plant

W = Water delivered to the field

3.6.3 WATER DISTRIBUTION EFFICIENCY

This explain the way water is distributed between the over head irrigation areas and surface irrigation areas of sugar cane plantation and the uniformity which may be done to the design of each of the method of irrigation being practiced.

It is expressed as follows:-

$$Ed = 100\left(1 - \frac{Y}{d}\right)$$

Where, Ed = Water distribution efficiency, percent

Y = Average numerical deviation in depth of water during irrigation.

D = Average depth of water stored along the run during the irrigation.

3.6.4 WATER USE EFFICIENCY

The water utilization by the crop is generally described in terms of water use efficiency in kg/ha or g/ha it can be defined in the following ways:-

CROP WATER USE EFFICIENCY"- It is the ratio of crop yeld (Y) to the amount of water depleted by the crop in the process of evaporation (E_T).

$$\text{Water use efficiency} = \frac{Y}{E_T}$$

FIELD WATER USE EFFICIENCY:- It is the ratio of crop yield (Y) to the total amount of water use in the field (W_R).

$$\text{Field water use efficiency} = \frac{Y}{WR}$$

3.6.5 CAUSES OF POOR WATER MANAGEMENT AT SUGAR PLANTATION, BACITA.

The problems stated below are the causes of poor water management in the cane plantation.

i) Seepage losses through unlined channels

ii) Transportation and siltation of canal by debris

iii) Particles which changes the design dimension of the irrigation canals

iv) Lack of proper supervision of irrigations by the concerned section managers.

CALCULATION OF CONSUMPTIVE USE OF WATER FOR SUGAR CANE AT BACITA BY USING BLANNY CRIDDLE FORMULA.

TABLE 1.80

MONTY	MEAN MONTHLY TEMPERATURE (T)	MONTHLY CROP CO-EFFICIENT	PERCENT DAY LIGHT HOURS (p)	MONTHLY CONSUMPTIVE USE (CM) U=ktp / 100	U MM/DAY
JAN	75.2	0.75	7.6	4.27	3.63
FEB	83.3	0.80	7.5	4.79	4.4
MAR	88.7	0.85	6.3	4.75	3.9
APR	88.7	0.85	9.0	6.79	5.8
MAY	84.2	0.90	8.3	6.29	5.4
JUN	81.5	0.95	7.3	5.65	5.9
JULY	79.9	1.00	5.8	4.62	3.9
AUG	78.8	1.00	5.2	4.98	3.47
SEPT	79.7	0.95	6.5	4.92	4.17
OCT	81.5	0.90	8.5	6.24	5.12
NOV	80.6	0.85	7.1	4.86	4.12
DE	77.0	0.75	7.9	4.56	3.74

U = 12 = 62.72CM

U = 5.8mm/day

MONTHLY MEAN MAXIMUM TEMPERATURE IN ^{O}C

TABLE: 1 . 1

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	34	38	37	37	33	32	30	30	31	33	34	35
1992	35	35	37	36	33	31	30	30	30	32	34	34
1993	32	38	39	40	35	31	30	30	32	33	36	36
1994	34	37	39	36	33	32	32	31	31	33	34	33
1995	36	36	38	36	33	30	29	30	30	34	35	33
1996	34	37	36	37	34	31	29	29	30	33	33	32
1997	35	38	37	39	39	33	32	31	32	32	35	34
1998	34	37	38	37	34	31	30	30	30	33	36	34
1999	33	36	37	37	33	32	31	30	31	32	35	34
2000	35	36	39	36	33	32	30	30	31	33	35	35
10YRS AVERAGE	34	37	38	37	38	32	30	30	31	33	35	34

SOURCE: NISUCO Meterological Station, Bacita.

MONTHLY MEAN MINIMUM TEMPERATURE IN ^{O}C

TABLE: 1 . 2

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	14	19	24	25	25	23	23	22	22	22	18	16
1992	17	21	24	25	24	23	22	22	22	22	19	16
1993	15	21	22	27	25	23	23	23	23	23	20	19
1994	16	19	26	25	24	23	23	23	22	23	20	17
1995	20	17	25	25	24	23	23	23	22	22	20	16
1996	16	23	25	26	25	23	23	22	22	22	20	15
1997	17	22	24	26	26	25	23	23	23	23	18	16
1998	19	21	26	26	25	23	23	23	23	22	19	18
1999	33	17	24	26	24	23	22	23	23	22	19	16
2000	19	19	21	25	23	23	23	23	22	23	21	21
10YRS AVERAGE	17	20	24	26	25	23	23	23	22	22	19	17

SOURCE: NISUCO Meterological Station, Bacita.

MONTHL RAINFALL IN MM FOR 10 YEARS PERIOD, BACITA

TABLE: 1 . 3

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	0	0	15	115	173	275	143	246	235	31	0	0
1992	0	29	51	129	60	141	106	140	126	98	0	0
1993	0	0	0	17	255	112	89	83	305	1	0	0
1994	0	0	11	112	133	103	152	234	248	75	0	0
1995	0	0	0	30	327	132	262	205	331	24	0	0
1996	0	16	47	27	95	253	135	156	155	53	1.2	0
1997	0	0	33	8	70	91	239	250	195	90	0	0
1998	2	8	0	79	92	178	188	107	154	62	0	0
1999	0	0	30	163	146	220	330	233	156	158	0	0
2000	0	16	0	215	197	172	439	245	232	90	0	7
10YRS AVERAGE	0.2	7	19	90	155	168	209	190	214	68	1.2	0.7

SOURCE: NISUCO Meterological Station, Bacita.

MONTHL MEAN EVAPORATION IN MM

TABLE: 1 . 4

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	5.8	8.2	8.6	8.6	5.8	5.3	4.5	0.4	4.8	5.6	6.0	5.6
1992	6.5	7.6	8.5	8.3	6.5	5.7	5.3	4.4	4.7	4.5	4.6	5.2
1993	6.4	8.1	8.6	9.7	8.0	5.9	0.8	4.3	4.5	5.2	6.1	5.6
1994	6.0	8.3	9.0	9.3	6.1	5.3	0.6	0.8	4.3	0.5	5.1	0.9
1995	6.1	7.5	8.3	8.6	6.7	4.7	0.3	0.1	4.2	4.9	5.6	6.7
1996	5.4	7.1	7.5	N.A	6.4	5.8	4.7	4.7	3.9	4.2	5.1	4.7
1997	5.5	7.6	8.8	9.4	8.9	5.4	0.7	4.3	0.4	0.6	5.4	5.2
1998	5.0	7.8	9.6	8.3	5.9	0.4	0.7	3.9	4.4	5.6	6.0	5.6
1999	6.0	7.9	7.8	8.5	5.9	0.8	4.8	4.5	4.2	4.7	5.9	5.1
2000	5.4	7.0	9.6	7.6	5.6	5.7	5.2	0.3	4.3	5.3	5.9	5.7
10YRS AVERAGE	5.8	7.7	8.7	7.9	6.6	5.3	4.7	4.4	4.4	5.0	5.6	5.4

SOURCE: NISUCO Meterological Station, Bacita.

MONTHLY WIND RUN IN KILOMETERS FOR 10 YEARS PERIOD, BACITA

TABLE: 1 . 5

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	29.47	80.02	119.14	148.56	88.31	80.05	79.71	60.52	60.10	42.99	41.96	39.12
1992	56.00	79.36	95.60	125.48	48.43	97.76	67.6	83.11	54.62	53.30	39.22	44.48
1993	59.11	81.00	86.89	142.95	134.00	72.82	79.88	87.94	50.06	38.02	50.22	52.43
1994	44.02	72.07	147.42	150.50	96.58	62.48	66.34	67.58	50.79	36.28	35.57	37.42
1995	72.49	52.98	114.52	98.40	110.93	69.25	54.59	38.26	30.68	26.14	38.90	34.95
1996	31.45	71.60	105.99	119.15	90.58	69.48	59.17	47.52	31.15	28.90	26.09	30.56
1997	40.94	62.62	100.96	84.95	124.87	73.21	52.72	39.34	35.11	23.33	27.11	22.21
1998	24.29	26.76	54.80	37.33	18.92	64.05	79.06	72.60	51.22	53.41	52.57	41.40
1999	43.02	58.43	93.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.88	34.3
2000	40.83	37.66	69.87	128.20	81.65	71.78	67.45	52.07	42.00	44.83	44.11	5.3.25
10YRS AVER AGE	44.16	62.24	98.88	103.51	79.43	68.09	60.65	54.89	40.63	34.73	40.06	39.01

SOURCE: NISUCO Meterological Station, Bacita.

MONTHLY MEAN PERCENT RELATIVE HUMIDITY

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	38	47	56	63	77	79	78	80	82	73	49	57
1992	41	46	59	67	74	79	79	77	79	77	80	56
1993	28	47	36	61	69	80	80	76	81	74	67	64
1994	49	40	60	64	72	70	76	80	78	76	65	48
1995	50	40	66	66	71	79	79	82	84	74	69	46
1996	46	65	71	67	69	79	78	78	82	73	72	47
1997	49	56	56	61	61	73	77	80	80	74	70	57
1998	52	80	62	63	70	78	78	77	80	73	64	51
1999	24	27	61	66	74	79	81	81	81	78	65	52
2000	50	39	40	66	75	77	82	81	78	73	71	76
10YRS AVER AGE	41	46	57	64	71	78	79	79	81	75	67	54

SOURCE: NISUCO Meterological Station, Bacita.

TABLE: 1 . 6

MONTHLY MEAN SUNSHINE RADIATION IN HOURS

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1991	7.6	7.5	6.3	9.0	8.3	7.3	5.8	5.2	6.5	8.5	7.1	7.9
1992	8.4	6.8	7.5	7.7	7.8	6.4	5.3	4.5	5.9	7.3	8.0	8.3
1993	5.5	8.4	7.1	7.3	8.2	6.9	6.1	4.3	6.6	6.5	8.6	8.0
1994	7.5	6.8	7.3	6.5	7.4	6.6	6.1	6.4	6.1	6.7	7.2	6.5
1995	7.1	7.2	6.3	6.4	7.2	7.2	5.6	6.6	5.5	7.7	8.7	5.9
1996	7.2	8.4	6.8	8.2	8.7	7.5	5.5	5.6	5.1	7.6	7.6	N.C
1997	8.0	N.C	7.0	8.1	N.C	N.C	N.C	N.C	6.6	7.3	N.C	N.C
1998	N.C	N.C	6.8	6.5	N.C	N.C	N.C	N.C	5.2	7.4	N.C	N.C
1999	N.C	N.C	N.C	N.C	N.C	N.C	N.C	N.C	N.C	N.C	N.C	7.4
2000	8.2	7.8	7.2	8.0	7.9	7.2	5.6	N.C	N.C	N.C	N.C	N.C
10YRS AVER AGE	5.9	5.3	6.2	6.8	5.6	4.9	4.0	3.3	0.8	5.9	4.7	4.4

SOURCE: NISUCO Meterological Station, Bacita.

TABLE: 1 . 7

CHAPTER IV

4.0 BASIC DESIGN PROCEDURE

The design of a sprinkler system first involves evaluating the general topographic conditions, soil, crop, type of sprinkler system (portable or permanent) and farm operators desire and finance for the field or farm in question.

4.1 WATER REQUIREMENT

The estimation of the water requirement (WR) of crops is one of the basic needs for crop planning on the farm and for planning of any irrigation project. Water requirement may be defined as the quantity of water, regardless of its source required by a crop. Water requirement includes the losses due to exvapotranspiration (ET) or consumptive use (CU) plus the losses during the application of irrigation water.

4.2 AVAILABLE WATER CAPACITY

Soil moisture between field capacity and permanent wilting point is referred to as readily available moisture. It is the moisture available for plant use. Hence the calculated water holding capacity can be used for the determination of net irrigation requirement and gross irrigation requirement.

$$A.W.C. = (FC - PWP)\% \times Rd \times Bd$$

Where AWC = Available water holding capacity

FC = Percentage moisture at field capacity

Rd = Root depth

Bd = Bulk density

4.2.1 CROP WATER REQUIREMENT

Infiltration rate for clay loam is 10mm / hour. The total area to be irrigated is 50 hectares.

Application efficiency (Assumed) is 75%

Bulk density is = 1.7g/cc

Field capacity = 18.2%

Permanent wilting point = 4.5%

Consumptive use = 8mm / day for design propose

Root zone depth = 45mm

Type of crop = sugar cane

$$AW = \frac{(FC - PWP)\% \times Bd}{100}$$

$$= \frac{(18.2 - 4.5) \times 1.7}{100}$$

$$= \frac{13.7 \times 1.7}{100}$$

= 0.2329 mm /m

= 2.329 cm / m

4.2.2 NET IRRIGATION REQUIREMENT (NIR)

It is the water which is required in the soil after all the soil moisture losses has taken place, and when the available moisture capacity in the soil has depleted to 50% .

NIR = readily available moisture (wet basis) X root zone depth X 50% deficit.

= 2.329 X 4.5 X .05

= 5.24025cm

4.2.3 GROSS IRRIGATION REQUIREMENT (GIR)

This is the amount of water required within the root zone dept of soil

from the pumping unit to the root zone area. The water covers all the losses from the intake to the root zone area to give net requirement depth with maximum efficiency for the sprinkler system design it is most considered that the losses should not exceed 30 percent and that its distribution efficiency of 70 percent.

$$GIR = \frac{\text{Net Irrigation Requirement}}{\text{Efficiency}}$$

$$= \frac{5.24025}{0.7}$$

$$= 7.4807 \text{ cm}$$

4.2.3 TIME OF IRRIGATION

This is the time or duration it will take the irrigation to supply water to the field based on the soil condition of the given project area.

$$\text{Time of Irrigation} = \frac{\text{Gross Irrigation Requirement}}{\text{Efficiency}}$$

$$= \frac{7.4807}{0.7} = 7.4807 \text{ hours}$$

$$= 7 \text{ hours}$$

4.24 IRRIGATION INTERVAL

The irrigation interval is the length of time allowable between successive irrigation during the peak consumption use of the crop.

$$\text{Irrigation Interval} = \frac{\text{Gross Irrigation Requirement}}{\text{Consumptive use}}$$

$$= \frac{7.4807}{0.8}$$

$$= 9.3508$$

$$= 9 \text{ Days}$$

$$\text{Area to be irrigated} = \frac{\text{Total Area Under Project}}{\text{Irrigation Interval}}$$

$= \underline{50ha}$

$= 5.55$ ha / day

$= 6$ ha / day

4.2.7 APPLICATION RATE

It is the rate at which a given quantity of water will be held to applied into the soil in given time (mm / hrs), therefore, it is most considered as the time when net application is made into the soil.

$$\text{Application rate} = \frac{\text{Gross Irrigation Requirement}}{\text{Application Time}}$$

$$= \frac{7.4807}{7.4807}$$

$= 1.00$ cm / hr

$=10.0$ mm / hr

4.3.0 FIELD LAYOUT SPRINKLER

4.3.1 SPACING OF RISERS

These are the spacing between riser to riser on lateral lines and

between laterals to laterals lines from the calculated application rate of sugar cane crop, while comparing with LANCER SPRINKLER (TWIN NOZZLE) performance characterize chart with (table of application)

the spacing of 18 X 18 meters with application rate of 10.37 mm / hour and nozzle discharge of 3.36 m^3 / hour, ie 0.933 L/ Sec is selected for the crop.

4.32 AREA IRRIGATION PER LATERAL SETTING

This is lateral spacing multiply by the number of pipe per lateral set.

18 X 39.6 = 7128 m^2 or 07128 hectares

4.3.3 AREA IRRIGATED BY EACH LATERAL PER DAY

This is Area Irrigated per lateral setting multiply by the number of lateral shifting per day (assuming 2 shifting per day).

0.7128 X 2 = 1.4256 hectares / day

4.3.4 NUMBER OF LATERAL POSITION ON THE MAIN LINE

Length of the main line divided by the lateral spacing

$\frac{324m}{18m}$ = 18.0m lateral position

4.3.5 AREA IRRIGATION PER DAY

This is Area Irrigated by each lateral per day multiply by the number of laterals per day.

1.4256 X 4 = 5.70 ha / day

4.3.6 NUMBER OF DAY REQUIRED TO IRRIGATE THE WHOLE PROJECT FIELD

This is the total area of the field divided by the area Irrigation per day

$$\frac{50\ ha}{5.70\ ha / day} = 8.77\ day$$

$\simeq$ 9 days

4.3.7 NUMBER OF SPRINKLER NOZZLE PER LATERAL

:- Length of lateral divided by the spacing of sprinkler

$$= \frac{320}{18} = 17.77 \times 2 \text{ (twin nozzle)}$$

$= 35.55$

$\Rightarrow$ 36 Nozzle

4.3.8 TOTAL NUMBER OF NOZZLE PER SETTING

Number of nozzle per laterals multiply by the Number of lateral per one setting

36 X 5 = 180 nozzle per setting

4.4.0 WATER DISTRIBUTION

4.4.1 DISCHARGE PER NOZZLE

This is determined from the LANCER SPRINKLER reference chart table…4.1……..Column 18 X 18 spacing of the paper and rainfall application rate 10.37 mm / hr, i.e. the Discharge from the chart is 3.36 m^3 / hr

4.4.2 DISCHARGE PER LATERAL LINE

This is number of nozzle on lateral line multiply by the discharge

of one nozzle.

$=\Rightarrow$ 36 X 3.36

= 120.96 m^3 / hour

4.4.3 DISCHARGE OF MAIN LINE

This is total number of laterals per setting multiply by the discharge

per day.

= $\Rightarrow$ 5 X 120.96

= 604.8m^3 / hour

4.5.0 NOZZLE SELECTED

The selection of nozzle is from LANCER SPRINKLER reference chart. Taking reference from the selected spacing which is 60 X 60ft (18 X 18m), the corresponding selected nozzle size is $^{15}/_{64}$ X $^{1}/_{8}$ (5.95mm X 318 mm). The nozzle pressure is 55 psi (39kg / cm ^{2}), The coverage area is 127ft (38.7m). The above specification was in accordance to the LANCER SPRINKLER series performance chart (see table attached).

4.5.1 NOZZLE COVERAGE AREA

The coverage diameter for each nozzle is 38.7m, that is when the sprinkler made one revolution. It will cover an area of 1176.44m^2 using the formula below.

Area of circle = $\frac{\pi d^2}{4}$

Also considering the wind velocity which may affect the performance of the application and as well as the coverage, it is considered that the wind is blowing at a speed of 4.3 kilometer per hour and this wind velocity cannot affect the nozzle performance. From Michael (647) irrigation theory and practice, wind speed ranging from 0 – 6.5 km / hr the maximum spacing should be 60% of the diameter of water spread of sprinkler.

4.5.2 DESIGN OF MAIN LINE

The main line is the pipe that conveys water from the irrigation water

source to the point of use with a minimum loss of water under maximum pressure condition. The total length of the main line is 324m with a standard pipe length of 4m and with standard diameter of 8 inches (203.2mm) and 6 inches (152.4mm).

The number of pipe required for the main line is given by total main line length divided by the standard pipe length.

$$\Rightarrow \frac{324}{4} = 81 \text{ pipes}$$

The main line must be large enough to withstand the water pressure classes of reinforced concrete asbestos pipe in regard to economical aspect.and discharge of 604.8m^3 / hour with minimum losses. Hence, the selection of the pipe to satisfy the above listed condition can be based on the

Specification conversion to meters

Pipe diameter = 8 inches

1 inch = 2.54 cm

8 inches = 2.54 X 8

= 20.32 cm

= 203.2mm

Thickness of the pipe wall selected;

1 inch = 2.54 cm X 0.094

= 0.24 cm

= 2.39 mm

4.5.3 PROFILE LEVELING OF MAIN PIPE LINE

After knowing the number of asbestos pipes for the main line, the

profile survey of the line is carried out. This is done to determine the excavation level of the main and sub main pipeline. Both the main and sub main pipe line can be buried to a depth of one meter (1m), to

prevent constant damage of the buried pipes by field heavy duty

machineries. Two different asbestos pipe sizes will be used for the line, therefore, the laying of the pipes in the trench will be in phases. The first phase is 8 inches (203 mm) diameter pipe to a distance of 200 meters and 6 inches (150mm) diameter to cover 124 meters.

The slope of the pipe line

$$\text{Slope} = \frac{\text{highest elevation} - \text{lowest elevation}}{\text{Total distance}}$$

$$\text{The slope for first phase} = \frac{77.25 - 76.08}{200} \times 100$$

$$= 0.585\%$$

$$\text{The slope for second phase} = \frac{77.32 - 76.08}{124} \times 100$$

$$= 1.0\ \%$$

The pressure head loss due to friction in the main line is obtained from irrigation theory and practice by A. M. Michael page 655. The allowable frictional loss for main lines lies between 3 – 12 m / 100 m.

Assuming 20.0cm diameter pipe, the friction loss in meter per 100m in main line asbestos pipe based on Scobey's formula kg = 0.0565 (according to A. M. Michael Irrigation Theory and Practice page 775) is 7.532m.

Therefore – $\frac{7.532}{100}$ X 324 X 0.0565 =1.37m

Assuming 15 cm diameter pipe, frictional loss = 5.06m

.: $\frac{5.060}{100}$ X0.0565 = 0.93m

Therefore, 15 cm diameter with 0.93m frictional loss is to be adopted.

4.5.4 DESIGN OF LATERAL LINE

Length of line = 320m

Considering 7.5cm diameter pipe with couplers

If one sprinkler discharges 0.90 L/Sec, 18 sprinklers will discharge = 18 X 0.90 L / Sec = 16.2 L / Sec.

From Irrigation theory and practice by A. M. Michael (771), the frictional loss in a 7.5 cm diameter pipe (Aluminum) with discharge 16.2 L /Sec is 19.7cm / 100m and the first sprinkler is one sprinkler interval from main line and correction factor is 0.38, Michael (654).

h = Frictional head loss

h = $\frac{7.85}{100}$ X 320 X 0.38

=9.55

The nozzle operating pressure is 3.50 kg / cm^2

But 1kg / cm^2 = 10m

Nozzle operating pressure = 3.50 X 10

= 35m

From Irrigation Theory and Practice by A. M. Michael the frictional loss in the pipe should not exceed 20% of the nozzle operating pressure head.

Therefore, with 35m nozzle operating pressure

$$20\% = \frac{20}{100} \times 35$$

$$=7.0m$$

Therefore the 7.5cm diameter aluminum pipe should be adopted.

4.5.5 PUMP SELECTION

Pumping plant is essential in many irrigation systems, pumping conditions of a pump determines the type of pump to be used. Several types of pumps are available to meet the demand of Irrigation. These includes the centrifugal turbine, submersible turbine, propeller air lift and reciprocating pumps.

4.5.6 CALCULATION FOR TOTAL DYNAMIC HEAD

The total dynamic head is the head of water that must be covered by pump in order to lift the required quantity of water at the required point in the field. This comprises of all the losses due to friction in the main line, laterals, elevation difference, elbows and couplings etc.

The aim of this calculation is to compare the total dynamic head the existing pump to that of the system. From A. M. Michael Irrigation theory and Practice, the total dynamic head for which pump is designed is (T. D. H) = Dynamic sunction lift friction head loss plus elevation difference plus height of riser plus pressure in nozzle.

1). DYNAMIC SUCTION LIFT

It is the sunction plus frictional head loss in the canal, where the sunction lift is the height of water level to the surface. From existing canal the sunction lift is equal to 3.2m frictional head loss of pipes (J. F. Douglas)

$$\text{Pipe} = \frac{FLQ^2}{3d^5}$$

where,

L = Length of pipe = 324

F = Coefficient of friction in pipe = 0.005

D = Diameter of pipe = 200mm = 0.2m

Q = Discharge from canal = $0.034m^3$ / Sec

$$.:hf = \frac{0.005 \text{ X } 324 \ (0.034)^2}{3 \text{ X } (0.2)^5}$$

= 1 .95m

Dynamic Sunction lift = 3.2 X 1.95 = 6.24m

II) Frictional head loss in main and lateral lines

Frictional head loss in main = 0.91m

Frictional head loss in lateral = 5.96m

III) Elevation difference:-

This is the difference between the highest point in the field and the lowest point

= 79.32 – 76.08

= 3.24m

IV) Height of riser pipe = 2m

V) Pressure head loss in the nozzle = 35m

VI) Fitting losses = 5% of (I + II + III + IV + V + VI)

$= {}^{5}/_{100}\ (1.95 + 6.87 + 3.24 + 2 + 35)$

= 2.453

T. D. H. = 1.95 + 6.87 + 3.24 + 2.453 + 2

= 16.5m

However the total Dynamic head (TDH) of the pump is 64m, which means it gives the required pressure for the system.

4.5.7 WATER HORSE POWER

This is the theoretical power required by a pump to lift a given quantity of water at a given head. This can be determined by the following equation.

W. H. P. = QH (From Irrigation Principles and Practices by Israelson and Hanson).

W. H. P = Water horse power

Q = Discharge in L / Sec

H = Total dynamic head

$$W.H.P. = \frac{34 \times 16.5}{273} = 2.05$$

4.5.8 BREAK HORSE POWER

It is the power delivered to the motor to lift the water and it is determined by using the following formula.

(Take the efficiency of the pump as 70%)

$$B.H.P = \frac{W.H.P}{0.7} = \frac{2.05}{0.7} = 2.93$$

1 Kilowatt = 1.34 Hp

Power required for the plant = 1.34 X 2.93

= 3.93 Kwatt

4. 5. 9 DIFFERENT PARTS OF SPRINKLER SYSTEM

A sprinkler system consist of a pump, main pipes, submain (where necessary) and lateral lines.

a) PUMP UNIT

A pump is considered to be part of sprinkler system. The pump lift water from the source and forces it to the distribution line through main line pipe.

b). THE MAIN LINE PIPE

This is the large diameter pipes that are laid and buried to convey water from the pump to the lateral lines. It can be laid down hill or up hill depending on the slope.

Hydrants are also placed along the main line at equal interval of 64 meters to each other and there will by five hydrants on the line.

c). THE LATERAL LINE

The lateral lines are used to take water from the mainline or submain line. The lateral lines are laid along the furrows of ridges. The lateral lines are connected to the hydrants by the use of valve elbow.

4.5.0 PUMP HOUSE CONSTRUCTION

The pump house is to be constructed at the bank of the main canal at an elevation of 79.08m above sea level. Before the installation of the pump, a layer of concrete foundation of 50cm thick is places on the foundation trench. The pump may be placed on the layer and be rigidly bolted.

After the installation of the pump on the foundation, it will be surrounded with a cement block of 15.24cm thick, both sides of the walls to have double glass windows for air cooling and easy ventilation. The walls will be built at 1.5 meters on both sides away from the pump. If the wall reaches the height of 304.8cm it will be roofed with corrugated roofing sheets and may be covered with ceiling board at the inner roofing to reduce sun heat radiation that may affect the pump.

4.6.1 CONSTRUCTION OF SUNCTION WELL

This is the main source of the pump in-take of water for delivery and it will be constructed within the main canal. Sunction well will be sited in front of the pump house and details of construction can be seen from the drawing.

The bed level of the sunction well will be 77.43 meters above sea level, and it will have a foundation layer of 10.6cm. It will be constructed just 1.5 meters from the bed level of the main canal and 2 meter from the pump house and 3.5 m from the main pumping unit. A concrete wall will be erected from the foundation layer up the height of 2.50 meters. The dimension of the sunction well is 2.5 X 2.5 X 2.5 meters, it will be 3.2m above sea level.

4.6.2 PUMP OPERATINON AND MAINTENANCE

i). **PUMP OPERATION:-** The operation of the pump must be according to the company's manual of operation being supplied by the makers of the pump. Care must be taken to consider all the guides for starting, shutting and priming of the pump.

ii). **PUMP MAINTENANCE:-** The maintenance of the pump is carried out by using the manual of maintenance for servicing the pump and fuel refilling at all the time of operation. Care must be taken to consider the ways of lubrication, filling of engine oil, cleaning all parts that may be dusty or carbon. The pump should be properly covered if the season of operation is over until the next season.

4.6.3 DRAINAGE OF THE AREA

The principle of removing excess water from the land is known as drainage. This can be accomplished by the use of small infield drains. For this project, since the field slope is moderate and in general direction towards a natural drain, the drainage systems of the field will be at the edge of the field and will carry the excess water to the surrounding bush.

CHAPTER V

5.0 ECONOMIC ANALYSIS

The Sprinkler Irrigation System embarked upon at Sugar Plantation, Bacita is to maximize the yield of sugar cane. The total cost of the system can be compared with the benefit derived from the project to determine the viability of the project.

5.1 ANNUAL FIXED COST

This includes all costs of taxes, interest on capital investment, water cost, cost of water pump and pump house construction cost / benefit analysis, cost of pipe lines and annual depreciation charges. To determine the cost of irrigation, the capital recovery factor (C. R. F) is used which conbines interest depreciation into one. By multiplying the initial cost of equipment with C.R.F the actual cost of equipment per year is obtained.

5.2 COST OF MAIN LINE AND ACCESSORIES

ITEM	DIAMETER OR SIZE	QUANTITY REQUIRED	UNIT PRICE (=N=)	TOTAL COST (=N=)
MAIN LINE				
Pipe	20cm X 4m	35	12,000	432,000
Reducer	15cm X 4m	10	1,500	15,000
Hydrants	20cm X 15cm	5	3,000	15,000
Tee Joint	10cm X 1m	5	2,000	10,000
Gilbolt	15cm	7	3,000	21,000
None return valve	15cm	5	6,000	30,000
Flow meter	20cm	1	2,000	2,000
End plug	15cm	1	1,000	1,000
TOTAL				526,000
LATERAL LINE				
Pipe	7.5cm X 9m	270	8,000	2,160,000
45^0 corner bend	7.5cm X 10cm	200	2,000	400,000
End plug	7.5cm	5	1,000	5,000
TOTAL				2,565,000
SPRINKLER				
Riser pipes	2.5cm X 2m	90	8,000	720,000
Sprinkler heads	3.17mm	90	3,000	270,000
Sprinkler socket	2.5cm	90	8,000	72,000
TOTAL				1,062,000

5.3 PUMP INSTALLATION COST

This includes the cost of cost construction of pump house, sunction well and placement of the pump in the project area.

ITEM	QUANTITY REQUIRED	UNIT PRICE (=N=)	TOTAL COST (=N=)
Tipper load of sand	4	600	2,400
Tipper load of aggregates	3	800	2,400
Labour cost		500	500
Cost of delivery pipe		15,000	15,000
Cost of installation		5,000	5,000
TOTAL COST			**20,800**

5.4 ANNUAL OPERATION AND MAINTENANCE COST

This is referred to as recurrent cost which includes cost of running and Maintaining pumping plant and personnel.

PUMPING OPERATION COST:- This will cover all the cost of labour and energy required to run the pump.

5.4.1 LABOUR COST

1). One Irrigation Assistance (Experienced) = 78,000 per annum

2). One pump operator = 63,600 "

3). One night watchman = 63,600 "

4). Two labourers = 50,00 X 2 = 100,000

TOTAL **305,200**

5.4.2 COST OF DIESEL FUEL

Fuel consumption of the pump per hour = 2 liters per hour

Hours of operation per day = 7 hours / shift X 2 = 14hours / day

Fuel consumption of the pump per day = 14 X 2 = 28 liters / day

Number of days per circle = 9days per circle

Fuel consumption per circle = 28 X 9 = 252 L/circle

Number of days per season = 152 X 28 = 5096 L/season

Cost of diesel fuel per liter = =N=27

Cost of diesel fuel per season = =N= 137,592.00

Total cost of pumping operation = =N= 442,792.00

Grand Total =

5.4.3 AGRICULTURAL OPERATION COSTS

This includes the cost of management, labour and agricultural operation per year.

5.4.3.1 SKILLED LABOUR COSTS

Agricultural Superintendent on salary grade level 07 = =N= 72,600 per annum.

Assistance Agricultural Superintendent on salary grade level 06 = =N= 66,000 per annum.

Agric field overseer on salary grade level 04 = =N= 50,000 per annum

Total cost = =N= 188,600 per annum.

5.4.3.2 COST OF WEEDING AND FERTILIZATION

Manual seasonal labour for weeding 50ha for sugar sane farm.

Labour rate per day = =N= 50.00

Number of labour required per hectare = 3

Cost of labour per hectare = =N= 50 X 3 = =N=150.00

Three weeding operation per season

Number of labour required for weeding 50 hectares = 50 X 3 = 150 labourers

Cost of labour for one weeding operation = 150 X 50= =N= 7,500.00

Cost of labour for three weeding operation 7,500 X 3 = =N= 22,500.00

Fertilizer broad casting at the rate of =N=850.00 per hectare

Cost of fertilizer application for the whole area 50 X 850 = =N= 42,500

Cost of ploughing and harrowing of the whole area at =N= 2,500 per hectare

50 X 2,500 = =N= 125,500

Total Agricultural Operation Cost = =N= 378,600

5.4.4 PUMP MAINTENANCE COST

This includes all service, which the engine required to make it reliable to the estimated life span.

i). Cleaning and Washing the Engine:-

4 Litres of petrol per service

Cost of petrol per litre = =N= 26.00

Cost of petrol per service = 4 X 26 = =N= 104.00

Two clearing services in a month

Six operating months in a season

Cost of clearing services per season

12 X 104 = N=1,248.00

ii) Lubricating services:-

4 Litres of engine oil per service

Cost of engine oil per litre = =N= 120

Cost of engine oil per service = 120 X 4 = =N=480.00

Change of engine oil required per month

Six operating month in a season

6 X 480 = =N= 2,880.00

iii) Replacement services:-

Change of oil filter

Cost of oil one oil filter = =N= 300.00

Number of oil filter replacement required per season is three (3)

Number of filters replaced per service = 2

Filter replaced per season = 2 X 3 = 6

Cost of replacement services per season = 6 X 300 = =N= 1,800.00

Cost of air filter replacement services per season = 3 X 200 = =N= 600.00, total cost of replacement services = 2,400.00

iv). Total Investment Cost = Cost of mainline and accessories + Pump Installation Cost + Operation and maintenance Cost + Cost of Pump

= 4,153,000 + 20,800 + 385,128 + 3,300,000

= 7,858,928.00

.: Cost per hectare per year = $\frac{\text{Total Investment Cost}}{\text{Area Cultivated}}$

$$= \frac{7,858,928.00}{50}$$

=157,178.56

5.5 CAPITAL RECOVERY FACTOR

1). MAIN LINE

Life span = 15 year

C. R. F. for 15 year at 5% interest level = 0.0963

Total Cost = =N= 526,000

Cost / Year = =N= 50,653.80

2). LATERAL LINE

Life span = 15 years

C. R. F. for 15 year at 5% interest level = 0.0963

Total Cost = =N= 2,565,000

Cost / Year = =N=247,009.5

3). SPRINKLER

Life span = 8 years

C. R. F. for 8 year at 5% interest level = 0.1547

Total Cost = =N= 1,062,000

Cost / Year = =N= 164,291.40

4). **PUMP**

Life span = 20 years

C. R. F. for 20 year at 5% interest level = 0.0802

Total Cost = =N= 3,300,000

Cost / Year = =N= 264,660

5.6 FARM INCOME

The only crop grown is sugar cane

The total project area is 50 hectares

Expected yield 70 tones of cane per hectare

5.7 COST OF REFINED SUGAR

One tonne of sugar = 20 bags of 50 kilogramme

One, 50 kilogramme bag of sugar cost =N= 3,000

Therefore one tonne of sugar = 20 X 3000

=N=60,000

TOTAL BENEFIT COST OF THE PROJECT

This is the amount of money which would be realised from the farm

Product. The average yield of sugar cane per hectare is 70 tonnes, which implies that after processing we have 7 tonnes of sugar, since 1000 tonnes of sugar cane equals 100 tonnes of processed sugar.

The expected tonnes of sugar from the project area

= 50 X 7 = 350 tonnage of sugar

if one tonne of sugar = 20 bags and one bag of sugar cost = =N= 3,000

Therefore the total output for the 50ha project area

= 350 X 20 X 3,000

= 21,000,000

5.5 THE COST BENEFIT RATIO

This is the ratio between the total investment per year and the benefit anticipated from the project per year.

$$\text{Cost Benefit Ratio} = \frac{\text{EXPECTED BENEFIT}}{\text{TOTAL INVESTMENT}}$$

$$= \frac{21{,}000{,}000}{7{,}858{,}928}$$

$$= 2.67$$

$$= 3$$

$$= 1:3$$

.Therefore, the benefit is greater than the Investment and this indicated that the project is viable and so it is ideal for execution.

CHAPTER VI

6.0 CONCLUSION AND RECOMMENDATION

From the results of discussion and design of sprinkler irrigation system, and cost analysis for the project, it indicates cost benefit ratio of 1:3 it can therefore be safely concluded that the project is feasible and economically viable.

RECOMMENDATION

I strongly recommend the following measure particularly to the field department of the company for necessary implementation:-

1). The field department should make the project realistic to the company and should endeavor to carry out the extension project of the designed area (W23/24 extension field)

2). The Estate plantation presently under surface irrigation should be converted to sprinkler irrigation system because its practice have shown from pass records of good cane yield and less labour involvement.

3). Adequate amount of money be set aside for the purchase of irrigation equipment such as irrigation pumps, main lines lateral lines and other related equipment.

4). The company should lay more emphasis in training of irrigation staff both at ordinary and higher levels by considering the Engineering nature of the work.

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