NEW EVAPOTRANSPIRATION COEFFICIENTS FOR MAIZE UNDER GREEN HOUSE CONDITION

BY

AYUBA PETER WUYAH

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CERTIFICATION

This is to certify that this project was carried out by AYUBA, PETER WUYAH REGISTRATION NO. 95/4451EA OF AGRICULTURAL ENGINEERING DEPARTMENT OF FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

.... 28/07/2001

ENGR (DR. N.A. EGHAREVBA DATE

(PROJECT SUPERVISOR)

.... 16/1/2001

EXTERNAL EXAMINER DATE

.... 24/01/01

ENGR (DR) M.G. YISA DATE

HEAD OF DEPARTMENT

DEDICATION

This project is entirely dedicated to my parent Mr. Ayuba Idzi and Mrs Salomi Ayuba Idzi and my nephew James Ariyo.

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to Almighty God for sparing my life and seeing me through this project.

I wish to express my humble appreciation with great satisfaction to my understanding and hard-working supervisor Engr (Dr) N.A. Egharevba for his cooperation given to me in the course of this research work.

I will like us to say a big thank you to my Head of Department, Engr (Dr) M.G. Yisa and all members of staff of the Department for their unrelenting effort and for giving me the necessary information required. Moreso I would like to thank Mallam B. Mohammed for his best support and guidance in making this project a success. I equally give my appreciation and thanks to my parent (Mr Ayuba Idzi and Mrs Salomi Ayuba) for their various contribution in one form or the other to make me whom I am today.

I am obliged to recognise my younger sisters Esther, Sarah, Elizabeth and Blessing and brother (Alexander) for their roles in making things easy for me, I pray that God will make their affairs an easy task for them all (Amen).

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CHAPTER ONE : INTRODUCTION

1.1 General background

Evapotranspiration is one of the principal components of field hydrological cycle. It has been defined as the quantity of water transpired by plants during their growth or related in the plant tissues plus the moisture evaporated from the surface of the vegetation expressed in depth of water lost and used in a specific time.

Soil moisture required in root zone can be considerably influence by the upward movement of water from the ground H_20 table (GWT).

In some cases this water represents the major source of water to the plants.

How much water will be transported into the root zone will mainly depends on the depth of the ground water table (GWT) due to capillary forces is great and the rate of flow is low for light-featured sandy soil. The distance is small and the rate of flow is high. Irrigation systems provides the need and amount of water that is needed by plants for their ~~regetatie~~ vegetative growth and development.

The water balance of an area depends on meterological factors influencing precipitation and cropstraspiration from plants and the soil and well as other factors influence of surface and sub-surface water movement soil infiltration, percolation and water storage capacity characteristics soils, crop species and develop storage and agricultural practices.

1.2 Aims of the Project

The project was carried out with the aim of establishing the follows:

1. To determine the crop evapotranspiration coefficient for maize.

2. To determine the effect(s) of water table depth on maize yield and maize water use.

1.3 Justifications of the Objective

In many developing countries like Nigeria a systematic investigation that attempts to assemble the various crop coefficients for various agro-ecological zones of Nigeria will be a great contribution to the food production effort in the country.

However, there is a need to develop local coefficients instead of using assumed and generalized values because crop coefficients varies both with the crop characteristics and the climatic factor among others.

CHAPTER TWO: LITERATURE REVIEW

2.0 Definition and Objectives of Irrigation

Irrigation is the artificial application of water to soil to supplement the water available from rainfall and the contribution to soil moisture from ground water for the purpose of crop production.

In an irrigation scheme the following are the objectives:

i. Ensure enough moisture essential for plant life.

ii. Provide crop insurance against short duration drought.

iii. Cool the soil and atmosphere to provide a congenial atmosphere for plant growth.

iv. Wash out or dilute harmful salts in the soil.

v. Soften the village pores.

vi. Reduce hazards of soil piping.

2.1 Methods of Irrigation

Irrigation is accomplished through the following methods:

1. Sprinkler irrigation.
2. Surface irrigation.
3. Sub-surface irrigation

2.1.1 Sub-surface Irrigation

Is irrigating by water movement upward from a water table located some distance below the soil surface. Some areas are naturally sub-irrigated where water table are within a metre or 2 metres of the soil surface.

Sub-surface irrigation is used for soils having a low water holding capacity and a high infiltration. This method is more efficient in water than other systems and is adopted only for special situation, in arid regions the upward movement of water and its evaporation at the soil surface results in salt accumulation, sub-surface irrigation works best where natural rainfall leaches any salts that may have accumulated. [Fundamentals of Soil Science pg 182-183]

2.2 Soil Physical Properties Influencing Irrigation and Crop Yield

Soil is made up of three phase components namely the liquid phase called soil moisture, solid phase made of minerals, organic matter and various chemical components and the gaseous phase called soil air. The solid phase includes soils particles and shape. Numerous lining organisms are included in the soil as its constituent and these organisms include bacteria, fungi, algae, protozoa. Insects and small animals which directly or indirectly affects soil structure and plant growth.

2.2.1 Soil Structure

In most soils the soil separates do not exist independently as single grains, instead they are bound together in dusters called aggregates. The smallest aggregate is termed "Ped"

The soil separates and the peds may further coalesce to form bigger aggregate of definite shapes which constitute soil structure.

The soil structure can be best studied in the field under natural conditions and it is described under three (3) categories, namely:

1. Type (shape/arrangement of structural units).

2. Classes (size of aggregates or peds).

3. Grade (degree of development or distinctiveness and durability or strength of the peds).

Aggregates are classified as fine, medium or coarse depending on their sizes, soil organic matter plays a major role in soil aggregation.

2.2.2 Soil Texture

Soil texture refers to the fineness or coarseness of the mineral particles of the soil and it is commonly defined as the relative proportions of sand, silt and clay. A soil texture classified as loam entails all three major size fraction occur in sizeable proportions. It is perhaps the most fundamental and most permanent soil property affected very little by normal soil management practices.

It exerts considerable influence on the capacity of the soil to hold water and to circulate air.

2.2.3 Soil Composition

Solid phase of the soil is composed of minerals constituents refers to as mechanical composition of soil.

It consists of rocks particles developed by action of weathering or deposition in bulk by wind or water. Mineral soil particles are classified according to their size.

Mechanical composition of soils are gravel, sand, salt and clay.

The gravel is of large size in diameter ranging between 2 cm and 2mm. Minerals of lesser than 2 mm in diameter are the fine earth, while salt and silt particles are approximately spherical or cubical in shape, clay particles are plate shaped.

2.2.4 Chemical Nature of Soils

The mineral components of soil are made largely of silica and silicates.

Chemical compositions differs from profile to profile which contains the larger particles higher silica while fine particles contain more potassium, calcium and phosphorus.

A dominant minerals are quartz in sand, quartz and fieldspores in fine sand and silt, mica, vermiculitic monilmorilonite kaolinite and amorphous colloids in clay. [Dr. Osunde 1998]

2.2.5 Plant Structure

The morphology of a plant consists of roots, stem and leaves.

Leaves are borne throughout stem in all plants. These organs are mainly responsible for the loss of water, pores and leaves are the stomata and sorounded by guard cells. The stomata regulate loss of water as vapour and exchange of carbondioxide in the leaf and other organs. The leaves maintain their continuity of structure with stems which was conducting tissues which are xylem and pholem. Xylem are the main channels of water transport. Root hair is largely involved in water uptake. [Michael 1978].

2.3 Circulation of Water and Nutrients in Plants

From previous research carried out it could be concluded that high water table affect the yield of maize and that lower water table favours the yield of crops (maize). The circulation of water from one cell to another cell is achieved through osmosis, which involves mass flow of water through pores of different permeable membrane.

Circulation of nutrients in plants involves irons from soil to root surfaces, ions accumulation in root cells, circulation of ions from root surfaces into the xylem and finally their translocation from roots to shoots. Plant nutrients like fertilizer. Fertilizers are substance that when applied to the soil supply those elements required in the nutrition of plants.

Tisdale and Welson (1968) reported that if fertilizers are properly applied to soil, it increases the productivity of soil.

Also Benjamin (1991) reported that when fertilizers (N) are applied their response by maize is dependent not only on the amount of nitrogen supplied but also on the prevailing environmental conditions namely temperature, humidity and moisture.

2.4 Evaporation, Transpiration and Evapotrans-pirations

Evaporation is a process which converts water into vapour, it occurs through absorption of heat energy.

Evaporation of liquid water transformation to vapour from open water, bare soil, or regulation with soil beneath. Transpiration occurs as that part of the total evaporation which enter the atmosphere from the soil through the plants.

Evapotranspiration – is one of the principal components of the field hydrological cycle, it is defined as the quantity of water transpired of plants during their growth or retained in the plant tissue plus the moisture evaporated from the surface of the soil and the vegetation expressed in depth of water lost or used in a specified time.

Penman (1947) concluded that potential evapotranspiration as the evapotranspiration from an activity growing short green vegetation completely shading the growth and never short of moisture availability. [J.R. Rydzeluski].

2.5 Water Relations of Soil

Ghuman and Maurya (1986) gave the assertion that irrigation water becomes very necessary due to the fact that a large amount of irrigation water would affect the suitability of the soil for crop production.

Water affects intensely many physical and chemical reactions of soil as well as plant growth. Soil serves as reservoir for water, pores spaces in soil on partly filled with soil air, liquid vapour and partly with liquid phase of soil water.

2.5.1 Movement of Water into Soils

The movement of water from the surface and through the soil is refer to as soil water intake. The movement of water in the soil involves various states and direction water moves and also the forces that cause the movement makes it complex.

2.5.2 Infiltration

It refers to the entry of water into the soil surface. Infiltration capacity is the measure of the extent a given soil under specified conditions can take in water.

It is also quantitatively found to be equal to the difference between the initial moisture content and the moisture content at saturation.

Infiltration rate is the rate of water entry into the soil.

2.5.3 Plant Water Relationship

The metabolic activity of cells and plants is closely related to their water content. Growth of plants is controlled by the rates of cell division and enlargement and by the supply of organic matter and inorganic compounds required for the synthesis of new protoplasm and cell walls.

Water plays a leading role in the photosynthesis of a plant.

Water is the major constituent of the living cell between 85% and 95% of the live weight of most plant tissues in plant.

Water in the living cells is a universal solvent that carries essential nutrients through the plant and allows critical chemical reactions to occur.

2.6 Maize (zea mays)

Maize may be grown as a rainfed crop and under irrigation.

BOTANY: It is an annual crop belonging to the grass family, it grows best in a rich well-drained neutral or alkaline soil because maize uses large quantities of nutrients from the soil, it gets materials in short numbers of days.

Height varies from 1.34m to 0.9m depending on the variety.

Male flowers called vassels emergy after 50-60 days at the apex of the plant

Female flowers called silks emergy from the leaf axills shortly after vasselling, the seeds are formed on cobs which are the compacted stalks of female inflorescences. The quality of maize determines its use.

Also maize forms the base of most livestock feeds and in particularly relished by poultry, cattle and pigs.

2.6.1 Maize Varieties and Yields

There are many different varieties of maize grown in West Africa, they are as follows:

1. Sweet maize – This is valued for its sweet flavour, this variety has a much higher sugar content than all the other types and it is usually eaten boiled or canned.
2. Popcorn – This is an extreme form of flint maize. It has small kernels (grains) on a small ear. It is fried in oil to make guguru. The starch granules are enclosed in a very tough and elastic membrane.
3. Floury maize   It consists of largely soft starch which is surrounded by the corneous layer under the pericarp. It is grown mainly in southerly parts of Nigeria.
4. Acut maize – It contains soft starch granules which are less densely packed than other types of maize. This result in the shrinkage of the starch within the outer layer of the grain.
5. Flinct Maize – It is very softly starch in its grains , examples of flinct maize include Samaru 123, NS-1 etc.

2.6.2 Climate and Soils

Temperature and rainfall affects the moisture requirement and generaly more moisture is needed under tropical condition than under temperate conditions.

Maize is sensitive to moisture around the vasselling and fertilisation and under tropical condition, a 15mm deficit of moisture in the 2 weeks around fertilisation will cause a great reduction in yield. Maize crop required optimal moisture at planting when the soil should be near field capacity.

Maize is grown on a wide variety of soils. One essential requirement however is good drainage. Maize crop will grow on moderately acidic soils but does best on soil with pH value of above 5.0. It can also be grown well on alkaline soils provided nutrients deficiencies are avoided.

2.6.3 Planting

Before sowing the land is cleared and tilled. The seeds are sown 2-4 cm deep at a spacing of 30 cm along the row. The space between row is 90 cm, usually 16-44 kg of seeds are sown per hectre for one crop.

Smaller varieties with more erect foliage have a higher yield potential, when planted more closely. Two or three seeds are sown per stand (hole).

2.6.4 Weed Control

Weeds do reduce the crop yields and maize is not an exception, the seeds should be planted on a well tilled soil, so that they can grow before the weeds fully develops.

Herbicides such as premixtrat, gisprin and gramoxone a non-selective herbicide is mixed and spray with the aid of the knapsack sprayer.

2.6.5 Insects Control

The treatment of the seeds with seeds dressing chemicals like Acetallic 2% liquid, Apron-plus are used before planting. Also the spray of insecticide like Karate 25 ec, cymbush 25 ec, Actdelic 25 ec are diluted with cleaned water and spray using the knapsack-sprayer.

2.6.6. Harvesting and Storage

Maize is harvested by hand in Nigeria and in most part of Africa.

Cobs are picked before they are fully ripe as sweet cob. Maize cobs are usually stored after being dried to 11 to 13 percent moisture content.

The grains are dried to ensure good storage and sprayed to kill any pests or disease already present.

CHAPTER THREE MATERIALS AND METHOD

3.0 Green House Description

The green house is located on the outskirts of Badeggi village on kilometre 43 on the Bida-Suleija high way in Niger State and situated in the southern guinea zone of the savanna region in latitude 9°45' North and longitude 6°07' East.

Badeggi has annual rainfall amount of 1158.2mm. The wet period falls within June to September, while the dry season is observed in November to March with less than 31.4 mm of rainfall.

Harmattan wind prevails for long period of time (December to March), temperature ranges from 30.8°c (September to December) to 36.7°c (March to April).

3.2 Green House

The experiment was set up in green house condition, the green house facilitates completely prevent rainfall for adequate study on the influence of sub-surface irrigation on the maize crop yield.

The main dimension of the green house are length is 13.2 m, breadth is 6.3 m and the height from ground floor is 1.25m, net mesh height from wall to rafter is 1.8 m. The green house is covered with white transparent plastic to allow radiation of sunlight for photosynthesis to take place.

For adequate water supply taps are installed in the green house to facilitate water application to crops.

3.3 Design of Experiment

Cylinderical containers were used for the experiment, the containers are of 400 mm and 720 mm for internal diameter and depth respectively. Five water table depths of 600 cm, 450 mm, 600 mm and 650 mm were used and with three replicates.

The control containers were performed at the bottom, sandy-loamy soil was put into each of the containers, water was applied to the containers till saturation was established at different water table depth level by stopage of water through the prezometers in the containers.

3.4 Data Observed

Water applied at 10 days interval (water use) was recorded using the measuring cylinder via the prezometer. Plant height, leave areas, number of leave, stem diameter were all recorded at 10 days intervals. N.P.K. fertilizer of ratio 20-10-10 was applied at 42 days after planting (aize seed). 5.0g of N.P.K. fertilizer was applied per 0.125 m^2(area of the container) with the recommendation of seven to twelve bags of 20-10 per hectare.

Soil physical properties were also determined at 20 days internal (bulk density, moisture content, probity, soil texture). The maize crop were harvested after 90 days at planting, the crop yield (dry matter grain) were dried to a constant weight and adjusted to 12.50% grain moisture on dry weight basis.

The result of the data observed are presented in Chapter 4.

3.5 Determination of Evapotranspiration Coefficients

The crop evapotranspiration (ETO) was determined using the blaney-morin-Nigeria ET model/Duru (1984).

$ETO = rf (0.45T + 8) (520 - R^{1.31}/1000$ 3.1

Where rf is the ratio of monthly maximum radiation to annual maximum radiation.

i.e. $rf = \frac{\text{monthly maximum radiation}}{\text{annual maximum radiation}}$

T = Temperature ^{o}C

R = Relation humidity %

ETO = Crop evapotranspiration mm/day.

CHAPTER FOUR RESULTS AND DISCUSSION

The parameters monitored during the dry season (Sept Dec. 1999) in the green house environment are discussed in this chapter.

4.1 Leaf Area

The raw data and analysed data of the leave measurement are presented in the Appendix (A). The statistical analysis for variance of leave area in table (4.12) shows that leaf area are significant from day one after planting up to 70 days after planting using the completely randomised design. It could be observed that at 75 days after planting the leave area are non-significant. Table (4.1.2) display the analysis of variance of leaf area. This indicates that leaf area were about the same dimension in length from the base to the tip and the maximum width irrespective of water table depth of the treatments.

However the leaf area difference became significant at from 25 days after planting at 1% level, 30 or 35 days after planting at 5% respectively as indicated in table (4.0). This shows that there are also difference in the rate of watter use at different water table deopth. From 68 to 90 days after planting some of the leaves were observed to be changing to yellow from green colour.

4.2. Plant Height

The raw data and analysed data of plant height are presented in the Appendix A.

The statistics analysis of variance of plant height in table (4.13) shows that plant growth response to water use of the plants in all the five (5) treatments. Plant height are significant at 1% level except at 25 days after planting which could be observed in table (4.13) that it is significant at 5% level.

Plant height is non-significant at 20 days after planting. This could be as a result of water up take rates at different depths.

It can be said that plant roots developed fast to enable it to tap soil moisture through capillary action even at deeper depth (65 cm).

4.3 Water Use

The raw data of water use is presented on Appendix (A) while the analysed data is given in table (4.14). The analysis of variance of water using statistical analysis shows that all treatments are significant at 1% level except at 20 days after planting which is significant at 5% level.

These considerable difference in water use are due to difference in water table depths in the containers in which plants were grown.

In table 4.2 it can be observed that water use at the 10 days interval are 3.01 cm, 1.29 cm, 1.35 cm, 1.12 cm and 1.23 cm for the 30 cm, 45 cm, 60 cm, 65 cm and free drainage of water table depths respectively.

The commulative water use for 90 days are given in table (4.3) the values are 62.87 cm, 46.64 cm, 40.68 cm, 30.44 cm, 25.29 cm for the water table depth at 30 cm, 45 cm, 60 cm, 65 cm and free drainage respectively.

TABLE 4.0

LEAVE AREA 20 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	X
30	0.01274	0.01664	0.01508	0.01482
45	0.02048	0.0185	0.01508	0.01802
60	0.01144	0.0102	0.02010	0.01391
65	0.0171	0.02516	0.02312	0.02177
FD	0.0168	0.0070	0.0189	0.01423

LEAVE AREA FOR 30 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	X
30	0.0243	0.0340	0.0377	0.0320
45	0.0384	0.0275	0.0362	0.0340
60	0.0360	0.0210	0.0363	0.0310
65	0.0396	0.0424	0.0436	0.0418
FD	0.0264	0.0406	0.0223	0.0277

LEAVE AREA FOR 40 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	X
30	0.0399	0.0832	0.0558	0.0596
45	0.0550	0.0480	0.0425	0.0480
60	0.0618	0.0468	0.0516	0.0534
65	0.0450	0.0520	0.0369	0.0446
FD	0.0460	0.0430	0.0534	0.0475

LEAVE AREA FOR 50 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	0.0842	0.0630	0.0480	0.0651
45	0.640	0.0530	0.0580	0.0583
60	0.0651	0.0510	0.0489	0.0550
65	0.0485	0.0530	0.0402	0.0325
FD	0.0588	0.0547	0.0588	0.0574

LEAVE AREA FOR 60 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	X
30	0.0600	0.0744	0.0552	0.0630
45	0.0630	0.0602	0.0736	0.0656
60	0.0630	0.0539	0.0623	0.0597
65	0.0609	0.0611	0.0108	0.0767
FD	0.0714	0.0630	0.0540	0.0628

LEAVE AREA FOR 70 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	0.0784	0.0588	0.0543	0.0638
45	0.0636	0.0420	0.0701	0.0588
60	0.0534	0.0672	0.0594	0.0600
65	0.0864	0.0824	0.0430	0.0706
FD	0.0624	0.0398	0.0654	0.0588

LEAVE AREA FOR 80 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	0.0684	0.0545	0.0614	0.0614
45	0.0640	0.0436	0.0538	0.0538
60	0.0568	0.0424	0.0496	0.0496
65	0.0120	0.0821	0.0570	0.0734
FD	0.0399	0.0604	0.0514	0.0505

LEAVE AREA FOR 90 DAP (m^2)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	0.0674	0.0539	0.0606	0.06007
45	0.0631	0.0421	0.0526	0.0526
60	0.0567	0.0417	0.0464	0.0481
65	0.0782	0.0781	0.0546	0.0708
FD	0.0374	0.0564	0.0441	0.0460

TALE 4.1

PLANT HEIGHT 20 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	20	16	21	19.00
45	20	21	18	19.67
60	16	18	16	16.67
65	20	24	19	21.00
FD	22	22	16	20.00

PLANT HEIGHT 30 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	28	25	26	26.33
45	29	25	27	27.00
60	26	31	36	31.00
65	30	28	34	30.67
FD	30	29	26	28.33

PLANT HEIGHT 40 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	38	45	37	40.00
45	61	60	52	57.67
60	51	72	67	63.33
65	59	70	66	65.00
FD	58	60	49	55.67

PLANT HEIGHT 50 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	82	92	88	87.00
45	84	100	110	98.00
60	88	103	62	84.33
65	88	93	84	88.33
FD	68	90	87	81.67

PLANT HEIGHT 60 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	X
30	80	109	70	86.33
45	90	89	102	93.67
60	91	110	119	106.67
65	98	100	92	96.67
FD	80	119	120	106.33

PLANT HEIGHT 70 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	82	110	71	87.67
45	94	91	103.6	96.20
60	91	111	120	107.33
65	160	102.8	98	100.27
FD	113	122	81	106.00

PLANT HEIGHT 80 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	126	114	71	103.67
45	154	116	110	126.67
60	100	108	134.6	114.20
65	128	130	99	119.00
FD	124	83	120	108.67

PLANT HEIGHT 90 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	126	113	72	104.33
45	153	116	110	126.33
60	100	107	135	114.00
65	127	131	98	118.67
FD	124	83	120	109.00

TABLE 4.2

WATER APPLIED 10 DAP (mm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE	DAILY Cu
	R_1	R_2	R_3	x	mm/day
30	29.70	30.10	30.40	30.00	3.01
45	25.40	20.80	22.40	22.85	2.29
60	21.40	19.40	10.90	17.27	1.73
65	13.10	17.30	8.80	13.05	1.31
FD	10.70	10.20	10.00	10.30	1.03

WATER APPLIED 20 DAP (mm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE	DAILY Cu
	R_1	R_2	R_3	X	mm/day
30	31.80	31.80	31.80	31.80	3.18
45	27.90	19.55	25.92	24.50	2.45
60	21.00	22.96	13.10	18.70	1.87
65	14.90	17.96	9.10	14.00	1.40
FD	11.92	10.74	10.53	11.05	1.11

WATER APPLIED 30 DAP (mm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE	DAILY Cu
	R_1	R_2	R_3	X	mm/day
30	29.89	35.92	36.71	34.20	3.42
45	27.10	24.34	24.74	25.40	2.54
60	26.18	23.80	13.94	20.35	2.04
65	15.94	18.10	19.70	14.70	1.47
FD	13.20	12.55	11.63	12.45	1.25

WATER APPLIED 40 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE	DAILY Cu
	R_1	R_2	R_3	x	mm/day
30	38.30	37.51	35.92	37.25	3.73
45	25.18	25.34	26.82	25.80	2.58
60	23.78	23.02	23.94	23.60	2.36
65	17.10	19.70	10.60	15.80	1.58
FD	14.10	13.20	13.07	13.45	1.25

WATER APPLIED 50 DAP (mm)

WATER TABLE DEPTH (cm)	RELICATES			AVERAGE x	DAILY Cu mm/day
	R_1	R_2	R_3		
30	41.14	35.87	39.10	38.70	3.87
45	25.00	27.72	30.92	27.95	2.80
60	20.00	25.72	15.92	21.00	2.40
65	19.70	20.10	12.20	17.50	1.75
FD	15.00	15.70	13.96	14.20	1.42

WATER APPLIED 60 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE x	DAILY Cu mm/day
	R_1	R_2	R_3		
30	44.22	42.63	41.04	42.60	4.26
45	26.67	30.69	30.69	29.35	2.94
60	23.53	26.32	27.12	25.65	2.57
65	21.94	21.14	13.35	19.15	1.92
FD	16.30	14.30	15.00	15.70	1.52

WATER APPLIED 70 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE x	DAILY Cu mm/day
	R_1	R_2	R_3		
30	47.80	46.23	44.93	44.65	4.47
45	31.44	31.04	32.50	31.50	3.15
60	24.32	28.52	27.90	26.90	2.69
65	22.94	15.35	23.14	20.45	2.05
FD	18.20	16.40	16.20	16.45	1.65

WATER APPLIED 80 DAP (mm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE x	DAILY Cu mm/day
	R_1	R_2	R_3		
30	20.00	32.73	36.73	29.8	2.98
45	22.25	24.73	23.53	23.50	2.35
60	21.00	23.30	25.40	23.25	2.33
65	19.40	20.40	13.40	17.75	1.78
FD	15.00	14.70	14.20	14.65	1.47

WATER APPLIED FOR 90 DAP (mm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE	DAILY Cu
	R_1	R_2	R_3	x	mm/day
30	04.80	23.53	25.12	24.45	2.45
45	19.25	22.43	23.13	21.60	2.16
60	19.40	19.90	21.40	20.15	2.02
65	17.60	15.40	11.40	14.80	1.48
FD	10.70	11.40	9.80	10.65	1.07

TABLE 4.3 Mean Water Applied (CM) at 10 days intervals

WATER TABLE DEPTH (cm)	DAYS AFTER PLANTING									
	10	20	30	40	50	60	70	80	90	Total (cm)
30	3.01	3.18	3.42	3.73	4.30	4.00	3.47	2.98	2.35	62.19
45	1.29	2.59	2.74	2.98	3.92	3.35	2.80	2.35	2.16	48.14
60	1.35	1.87	2.04	2.60	3.50	3.10	2.50	2.33	2.02	40.69
65	1.12	1.40	1.52	1.58	2.40	2.70	2.40	1.80	1.50	33.34
FD	1.03	1.40	1.51	1.72	2.20	2.10	1.70	1.60	1.30	28.09

4.4 Stem Diameter

The rate data of stem diameter is presented on Appendix (A) while the analysed data is given in table (4.4). The analysis of variance of stem diameter using statistical analysis shows that all treatments are non-significant at 5%. This shows that the difference between the different treatments is neglible from table (4.15).

TABLE 4.4

STEM DIAMETER 20 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES R_1	R_2	R_3	AVERAGE x
30	24.60	26.70	28.10	26.47
45	23.40	26.20	22.10	23.90
60	22.00	27.40	21.00	23.33
65	20.60	25.40	23.10	23.37
FD	19.60	22.60	21.00	21.07

STEM DIAMETER FOR 30 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES R_1	R_2	R_3	AVERAGE x
30	25.60	27.40	28.65	27.22
45	24.60	26.40	22.40	24.47
60	22.70	27.40	21.60	23.90
65	21.60	26.40	24.80	24.33
FD	19.80	23.80	21.10	21.57

STEM DIAMETER FOR 40 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	28.00	29.50	30.00	29.17
45	27.00	28.60	24.40	26.67
60	25.00	30.00	24.60	26.53
65	24.50	29.80	30.00	28.10
FD	23.70	26.70	26.50	25.63

STEM DIAMETER FOR 50 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	32.00	30.00	30.00	30.07
45	30.00	30.00	28.00	29.33
60	25.00	32.00	27.00	26.00
65	27.00	32.00	37.00	30.00
FD	26.00	28.00	27.00	27.00

STEM DIAMETER FOR 60 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	29	30	29	29.33
45	28	24	28	26.70
60	27	29	27	27.67
65	28	30	31	29.67
FD	29	25	28	26.67

STEM DIAMETER FOR 70 DAP (cm)

WATER TABLE DEPTH (cm)	REPLICATES			AVERAGE
	R_1	R_2	R_3	x
30	30	30	28	29.33
45	27.50	25	28	26.83
60	27.00	28	27	27.33
65	29.00	30	30	29.33
FD	28.00	24	26	26.00

treatment are significant at 5% except at 40 to 50 days after planting that are significant at 1%.

Also the number of leaves shows that the number of leaves vary with the plant growth stages.

4.6 Evapotranspiration Versus Water Use

The evapotranspiration of the crop (maize) using Blaney Morin Nigeria model could be observed in Table (4.11) which indicate high monthly consumptive use within the vegitable growth period of 30-60 days after planting. The actual water use for water table depth of 30 cm, 45 cm, 60 cm, 65 cm and free drainage as follows: 62.87 cm, 46.64 cm, 40.58 cm, 30.44 cm and 25.99 cm respectively as shown in table 4.3.

4.7 Grain Yield

The GRAINS yield at various water table depths are shown on Table 4.5 and with the analysed result. The statistical analysis of variance of grains yield shows that grain yield are significant at 1% level.

It could be observed that the treatments beginning with high water application depth and production increased rapidly with increase in water application depth. The 30 cm water table yielded 0.6583 kg of grain with cummulative water use of 62.87 cm.

The 45 cm water table depth produced 0.0455 kg of grain with cummulative water use of 46.64 cm. The 60 cm water table depth gave 0.0365 kg of grain with cummulative water use of40.58 cm, the 65 cm water table depth gave 0.0293 kg of grain with cummulative water use of 30.44 cm and the free drainage yielded no grain with cummulative water use of 25.29 cm, as shown in Table 4.3 shows the treatments of 30 cm and 45 cm water table depth recorded high grain yield but 65 cm is lower. The 30 cm water table depth gave good free drainage and available soil moisture for plant growth. Graphical presentation of grains yield and water use is shown in fig. (4.5).

TABLE 4.5

Grain Yield (kg) [grain yield per container]

WATER TABLE DEPTH (cm)	REPLICATES				AVERAGE x
	R_1	R_2	R_3	TOTAL	
30	0.2194	0.3140	0.1249	0.6583	0.2194
45	0.0151	0.0175	0.0131	0.0453	0.0151
60	0.0121	0.0124	0.0120	0.0365	0.0122
65	0.0121	0.0144	0.028	0.0293	0.0098
FD	-	-	-	-	-

TABLE 4.6

Summarized table of Grain Yield (Kg) per container

WATER TABLE DEPTH (cm)	MINIMUM YIELD (kg)	MAXIMUM YIELD (kg)	MEAN YIELD (kg)
30	0.01249	0.3140	0.2194
45	0.0131	0.0170	0.0151
60	0.0120	0.0124	0.0112
65	0.0022	0.0028	0.0020
FD	-	-	-

TABLE 4.7

ANALYSIS OF VARIANCE OF GRAIN YIELD

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE	MEAN SQUARE	COMPUTED F	TABULAR F 5%	1%
TREATMENT	4	$1.064X10^{-1}$	$2.66X10^{-2}$	18.33	3.48	5.99
ERROR	10	$-1.451X10^{-2}$	$-1.45X10^{-3}$			
TOTAL	14	$9.183X10^{-2}$				

Cv = 74.26%
b** = significant at 1% level.

TABLE 4.8

Stover Yield (kg)

WATER TABLE DEPTH (cm)	REPLICATES			TOTAL	AVERAGE x
	R_1	R_2	R_3		
30	0.0450	0.025	0.015	0.085	0.0283
45	0.0310	0.0240	0.0280	0.083	0.02770
60	0.0157	0.0324	0.0257	0.0738	0.02460
65	0.0240	0.0215	0.0175	0.0630	0.0210
FD	0.0121	0.0182	0.0037	0.0340	0.01133

TABLE 4.9

Summarized table of Stover Weight (kg) per container

WATER TABLE DEPTH (cm)	MINIMUM WEIGHT (kg)	MAXIMUM WEIGHT (kg)	MEAN WEIGHT (kg)
30	0.0350	0.0450	0.0283
45	0.0240	0.0310	0.0277
60	0.0157	0.0624	0.0246
65	0.0175	0.0240	0.0210
FD	0.0037	0.0182	0.0113

TABLE 4.10

Analysis of Variance of Stover weight

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABULAR F 5%	1%
TREATMENT	4	$5.49X10^{-4}$	$1.45X15^{-4}$	1.9	3.48	5.99
ERROR	10	$7.62X12^{-4}$	$7.62X10^{-5}$			
TOTAL	14	$1.34X10^{-3}$				

Cv = 38.65%

4.8 <u>Crop Coefficient (k_C)</u>

K_c presents the relationship between reference evapotranspiration (ETO) and crop evapotranspiration (ETC) or ETCrop = K_c.ETO.

Where ETCrop is the rate of evapotranspiration of a disease. Free crop growing in a large field under optimal soil conditions, including sufficientn H_20 and fertilizer and achieving full production potential of that crop under given growing environment, including H_20 loss, through transpiration by the vegetation and evaporation from the soil surface and wet leaves, mm/day.

While ETO is the evapotranspiration from an extensive surface 8 to 15 cm tall, green grass cover of uniform height actively growing, completely shading the ground and not short of water.

The values of the given are shown to vary with the crop, its stages of growth, growing season and the prevailing weather conditions.

The crop coefficient (K_c) is obtained by linking the actual crop evapotranspiration (ETcrop) to reference crop evapotranspiration (ETO) as given in the equation below:

$$K_c = \frac{Etcrop}{ETO}$$

The Etcrop is obtained directly by recording the amount of water added to crop at 5 days intervals while the ETO values are obtained by using the Blaney-Morrin-Nigeria model.

The crop evapotranspiration of maize throughout the growing season and the cummulative water use shows a relatively lower values of evapotranspiration at the beginning of growing stages and increases during the period of rapid growth to a maximum and declining at maturity.

The values of crop coefficients (K_c) obtained ranges between 0.32 and 1.20 for thedifferent treatment (H_20) at different period of growing stages. The variation in these values establishes the fact that the crop coefficient varies with stages of crop maturity and time of the year and most importantly, it is influenced by the prevailing weather condition (rainfall and temperature) at any given period of time. The K_c curves are shown in Fig. 4.2 for 30 days intervals and fig. 4.1 for only 30 cm water table depth.

The crop coefficient values generated are presented on table 4.11a to 4.11E.

TABLE 4.11(a)

Country: Nigeria Latitude: 9°45'N

Place: Bida Altitude:

Crop: Maize ETO Method: B.M.N.

Date of Planting: Mid-Sept.

Max. Crop duration: 90 days

MONTH	10-DAY PERIOD NO	ETO (mm)	ET CROP (mm)	K_c	CROP GROWTH STAGE
SEPT.	1	3.17	3.01	0.56	Initial
OCT.	2	3.24	3.18	0.95	Initial/crop Dev.
	3	3.36	3.42	1/01	Crop Dev
	4	3.50	3.73	1.10	Crop Dev
NOV	5	3.71	4.30	1.20	Crop Dev
	6	3.59	4.00	1.11	Mid-season
	7	3.43	3.47	1.00	Mid-season
DEC	8	3.35	2.91	0.86	Late
	9	3.01	2.35	0.78	Late

WATER TABLE DEPTH: 30 cm

TABLE 4.11 (b)

Country: Nigeria Latitude: 9°45'N

Place: Bida Altitude:

Crop: Maize ETO Method: B.M.B.

Date of Planting: Mid-Sept.

Max Crop duration: 90 days

MONTH	10-DAY PERIOD NO	ETO (mm)	ET Crop (mm)	K_c	CROP GROWTH STAGE
SEPT.	1	3.17	1.45	0.46	Initial
OCT.	2	3.24	2.59	0.79	Initial/crop Dev
	3	3.36	2.74	0.82	Crop Dev
	4	3.50	2.98	0.85	Crop Dev
NOV.	5	3.71	3.92	1.06	Crop Dev
	6	3.59	3.35	0.93	Mid-season
	7	3.43	2.80	0.82	Mid-season
DEC	8	3.35	2.35	0.70	Late
	9	3.01	2.16	0.65	Late

WATER TABLE DEPTH: 45 cm

TABLE 4.11 (d)

Country: Nigeria Latitude: 9°45'N

Place: Bida Altitude:

Crop: Maize ETO Method: B.M.N.

Date of Planting: Mid Sept,.

Max. crop duration: 90 days

MONTH	10-DAY PERIOD NO.	ETO (mm)	ET CROP (mm)	K_c	CROP GROWTH STAGE
SEPT.	1	3.17	1.4	0.35	Initial
OCT.	2	3.24	1.52	0.43	Initial/crop Dev.
	3	3.36	1.90	0.44	Crop Dev
	4	3.50	2.40	0.54	Crop Dev
NOV	5	3.71	2.60	0.7	Crop Dev
	6	3.59	2.40	0.67	Mid-season
	7	3.43	1.95	0.57	Mid-season
DEC	8	3.35	1.80	0.54	Late
	9	3.01	1.50	0.5	Late

WATER TABLE DEPTH: 65 cm

TABLE 4.11 (d)

Country: Nigeria   Latitude: 9°45'N

Place: Bida   Altitude:

Crop: Maize   ETO Method: B.M.N.

Date of Planting: Mid Sept,.

Max. crop duration: 90 days

MONTH	10-DAY PERIOD NO.	ETO (mm)	ET CROP (mm)	K_c	CROP GROWTH STAGE
SEPT.	1	3.17	1.4	0.35	Initial
OCT.	2	3.24	1.52	0.43	Initial/crop Dev.
	3	3.36	1.90	0.44	Crop Dev
	4	3.50	2.40	0.54	Crop Dev
NOV	5	3.71	2.60	0.7	Crop Dev
	6	3.59	2.40	0.67	Mid-season
	7	3.43	1.95	0.57	Mid-season
DEC	8	3.35	1.80	0.54	Late
	9	3.01	1.50	0.5	Late

WATER TABLE DEPTH: 65 cm

TABLE 4.11 (c)

Computation Of Crop Water Requirements

Country:	Nigeria	Latitude:	9°45' North
Plate:	Bida	Altitude:	
Crop:	Maize	ETO Method: B.M.N.	
Date of Planting:	Mid Sept.		
Max. Crop duration:	90 days		

MONTH	10-DAY PERIOD NO	ETO (mm)	ET CROP (mm)	K_c	CROP GROWTH STAGE
SEPT.	1	3.17	1.03	0.32	Initial
OCT	2	3.24	1.20	0.37	Initial/crop Dev.
	3	3.56	1.40	0.42	Crop Dev
	4	3.50	1.80	0.51	Crop Dev
NOV	5	3.71	1.10	0.59	Crop Dev
	6	3.59	1.95	0.54	Mid-season
	7	3.43	1.70	0.49	Mid-season
DEC	8	3.35	1.6	0.48	Late
	9	3.01	1.30	0.43	Late

WATER TABLE DEPTH : FREE DRAINAGE

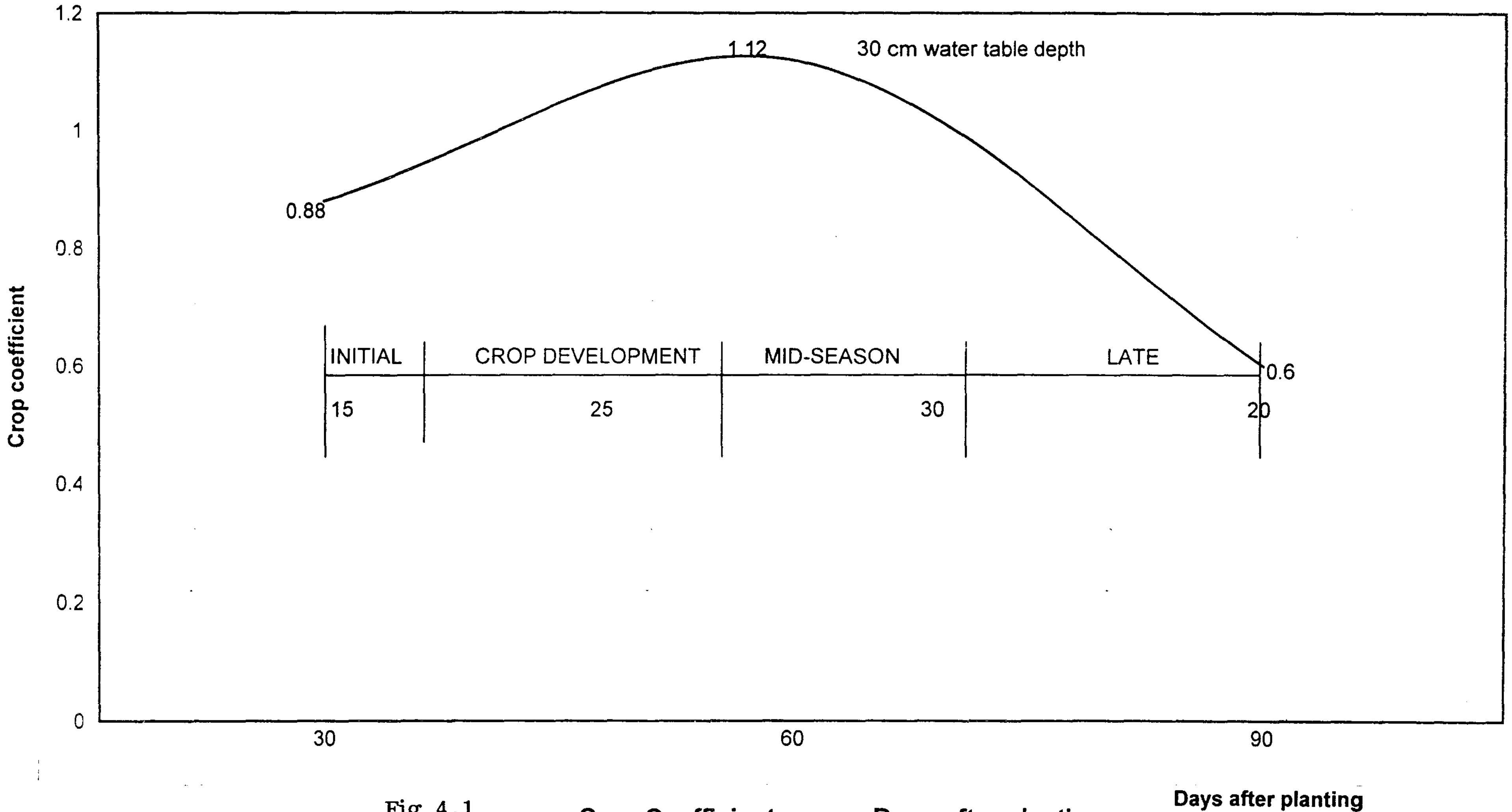

Fig 4.1 **Crop Coefficient versus Days after planting**

Chart1

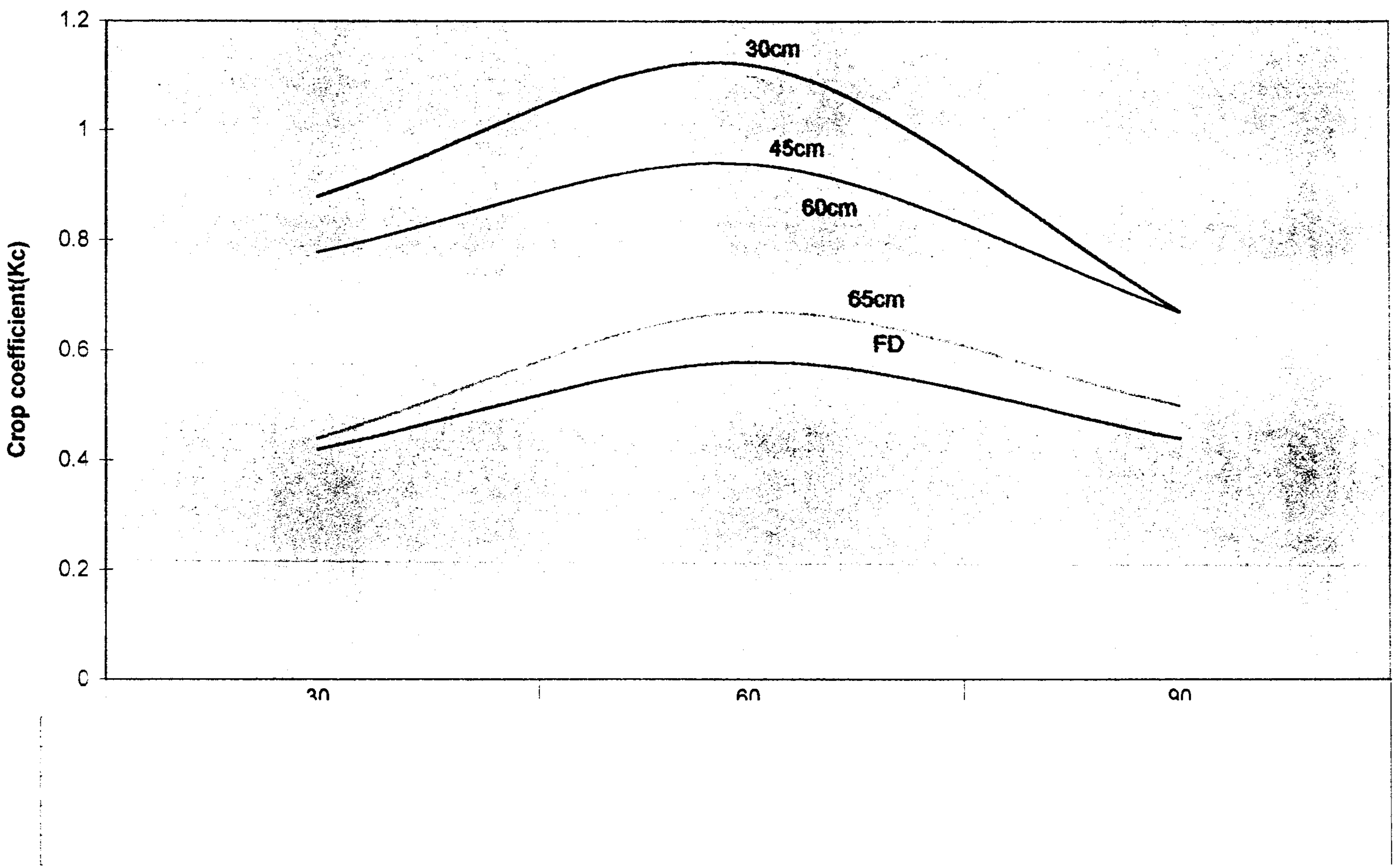

Fig 4.2 Crop Coefficient Versus Days After Planting

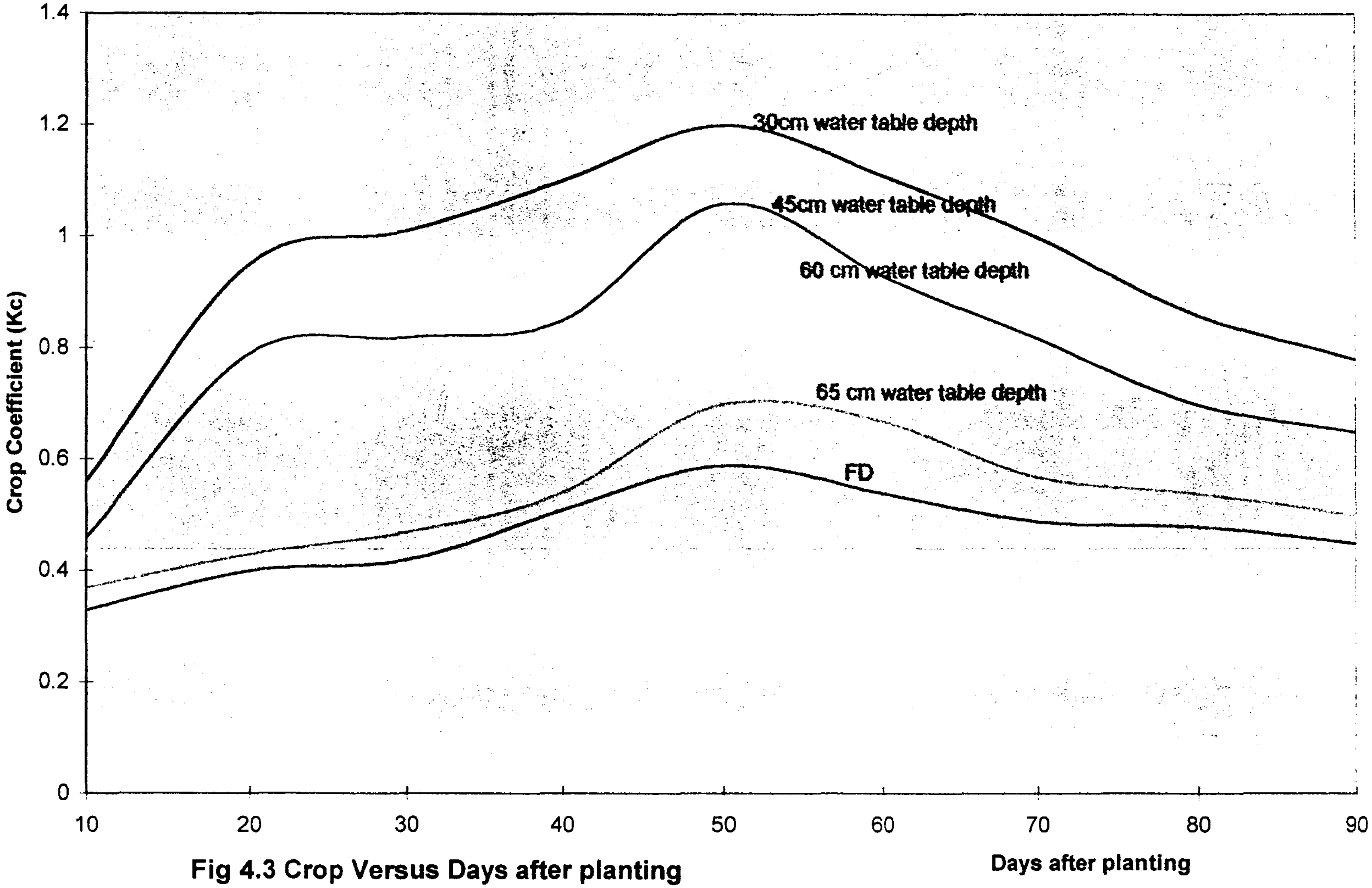

Fig 4.3 Crop Versus Days after planting

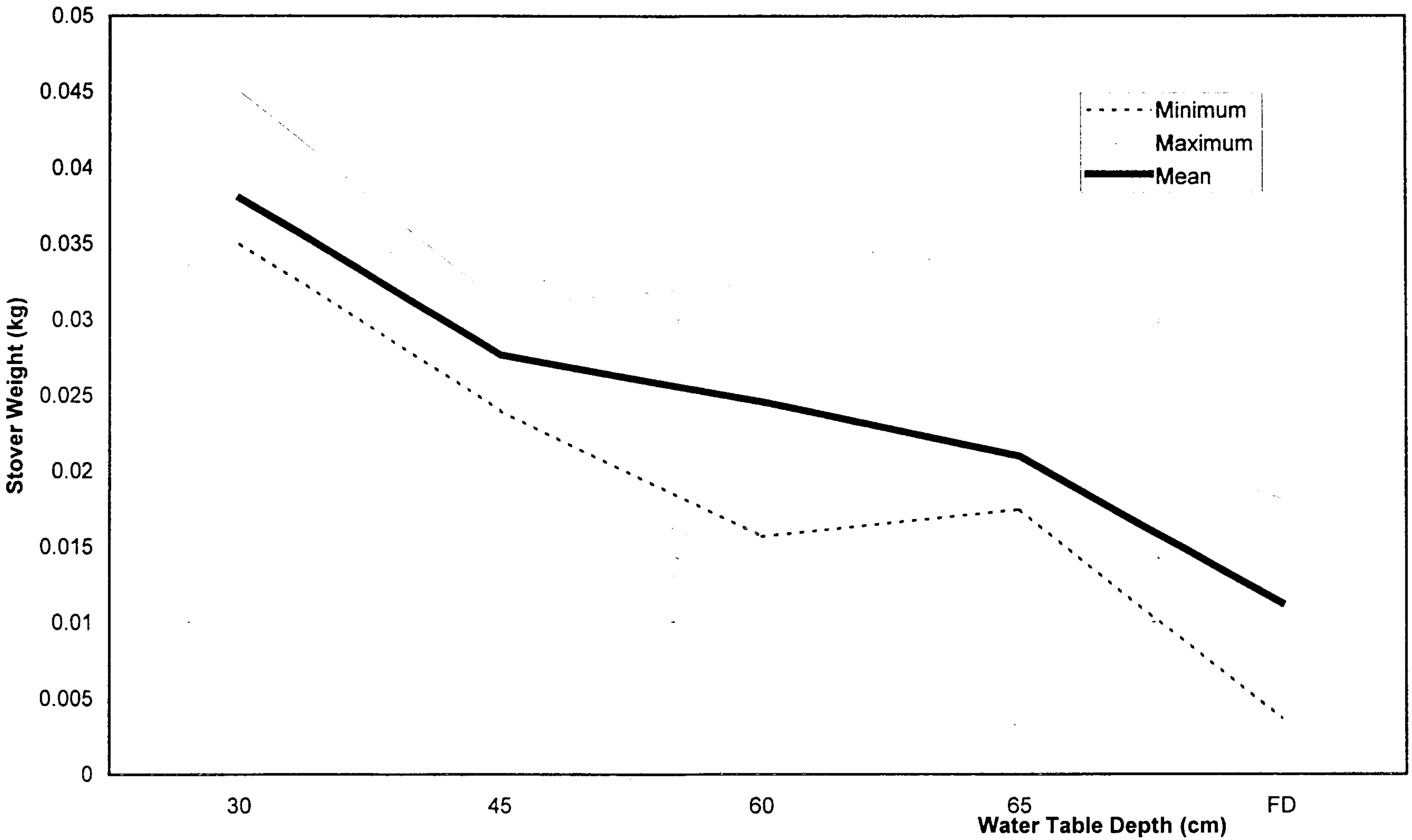

Fig. 4.4 The Effect of Water Table on Stover weight (kg)

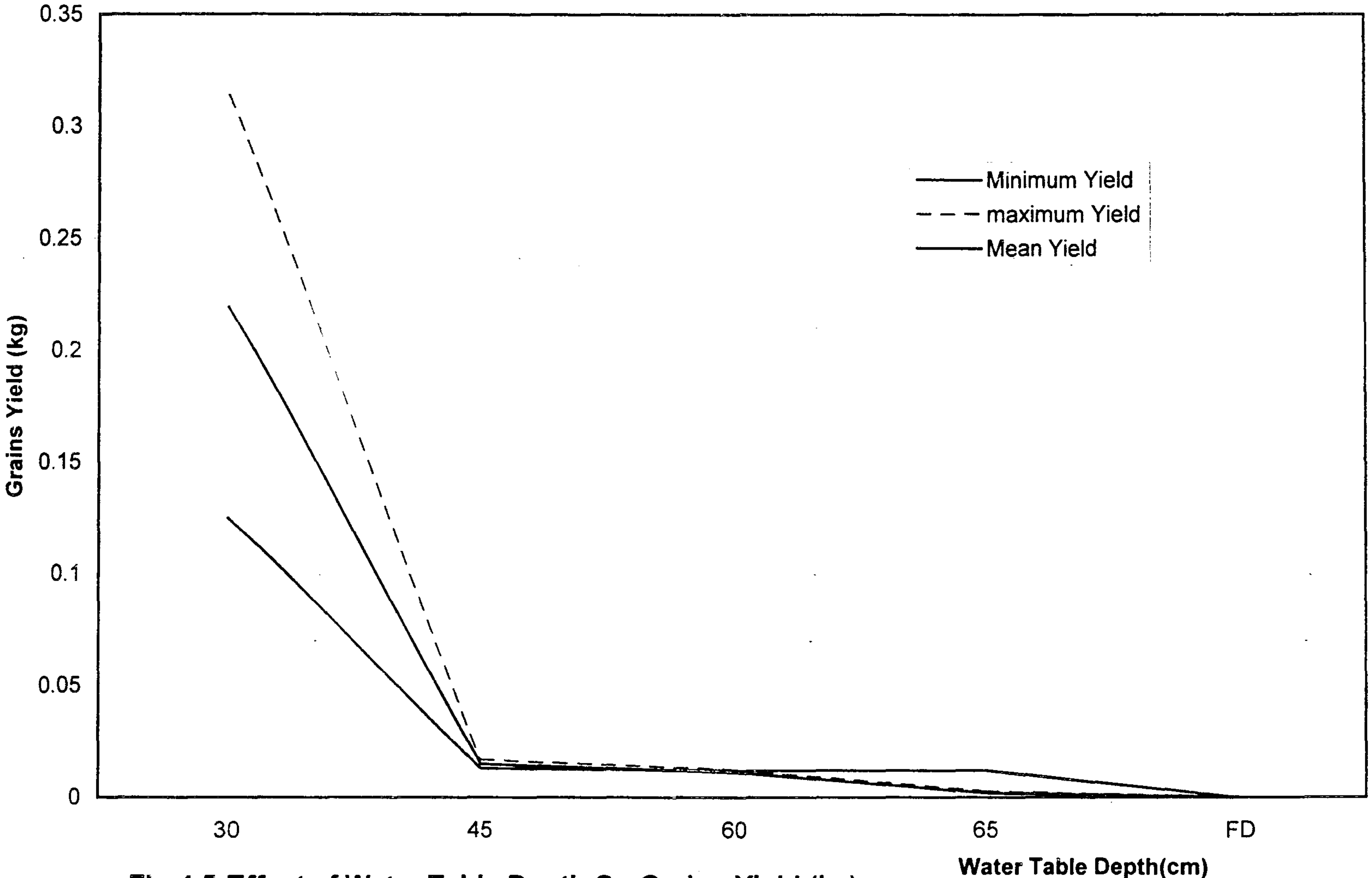

Fig 4.5 Effect of Water Table Depth On Grains Yield (kg)

PLATE 1: Pictorial view of maize crop 55 days after planting.

PLATE 2: Pictorial view of maize crop 75 days after planting.

CHAPTER FIVE CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The following conclusion can be established that:

1. Crop (maize) yield increased rapidly with decrease in water table depth (300 mm water table depth gave the highest grain yield while 650 mm water table depth gave the least grain yield).
2. The crop coefficient (K_c) values generated ranges from 0.88 to 1.12 and felt to 0.6 for the initial, developmental, mid season and late stages of the crop development for the 300 mm water table depth which gave the highest grain yield (0.6583 kg)
3. The values of crop coefficient (K_c) largely depends on the level of reference crop evapotranspiration (ETO) and the frequency with which the soil is wetted by irrigation.

5.2 Recommendation

The following recommendation are suggested:

1. The establishment of crop coefficient values (K_c) for maize should be conducted throughout the entire year as opposed to the convectional growing season used in this study.
2. Water table depth of 300 mm and 450 mm are recommended for maize (DMR-Yt) when operating under shallow water table condition for sandy loamy soils.

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APPENDIX A

TABLE 4.12

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 20 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 5%	1%
TREATMENT	4	$1.265X10^{-2}$	$3.17X10^{-3}$		3.48	5.99
ERROR	10	$2.172X10^{-4}$	$2.172X10^{-5}$	145.91**		
TOTAL	14	$3.344X10^{-4}$				

Cv = 28.16%

b** = Significant at 1%

ANALYSIS OF VARIANCE OF LEAVEA AREA FOR 30 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 5%	1%
TREATMENT	4	$2.750X10^{-4}$	$6.875X10^{-5}$		3.48	5.99
ERROR	10	$5.349X10^{-4}$	$5.349X10^{-5}$	1.28*		
TOTAL	14	$8.099X10^{-4}$				

Cv = 21.67%

b** = Significant at 5%

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 40 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR 5%	F 1%
TREAMENT	4	$4.236X10^{-4}$	$1.059X10^{-4}$		3.48	5.99
ERROR	10	$1.269X10^{-3}$	$1.267X10^{-4}$	8.36**		
TOTAL	14	$1.69X10^{-3}$				

Cv = 70.32%

b** = Significant at 1%

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 50 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR 5%	F 1%
TREATMENT	4	$1.839X10^{-3}$	$4.596X15^{-4}$		3.48	5.99
ERROR	10	$4.496X10^{-3}$	$4.496X10^{-4}$	75.16**		
TOTAL	14	$6.335X10^{-3}$				

Cv = 39.5%

b** = Significant at 1%

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 60 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 5%	TABULAR F 1%
TREATMENT	4	$1.317X10^{-4}$	$3.29X10^{-5}$		3.48	5.99
ERROR	10	$9.612X10^{-4}$	$9.612X10^{-5}$	1.37^{ns}		
TOTAL	14	$1.093X10^{-3}$				

Cv = 15.69%

b = Non-significant

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 70 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 5%	TABULAR F 1%
TREATMENT	4	$3.071X10^{-4}$	$7.68X10^{-5}$		3.48	5.99
ERROR	10	$1.39X10^{-3}$	$1.394X10^{-4}$	5.51*		
TOTAL	14	$1.702X10^{-3}$				

Cv = 18.93%

b* = Significant at 5%

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 80 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	$1.181X10^{-3}$	$2.953X10^{-4}$		3.48	5.99
ERROR	10	$5.563X10^{-3}$	$-5.563X10^{-4}$	1.00^{NS}		
TOTAL	14	$-4.154X10^{-3}$				

Cv = 40.83%

b = Non-significant

ANALYSIS OF VARIANCE OF LEAVE AREA FOR 90 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	$1.24X10^{-3}$	$3.103X10^{-4}$		3.48	5.99
ERROR	10	$-8.748X10^{-3}$	$-8807X10^{-4}$	$-3.55X10^{ns}$		
TOTAL	14	$-7.51X10^{-3}$				

Cv = 53.16%

b = Non-significant

ANALYSIS OF VARIANCE OF PLANT HEIGHT FOR 40 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	1179.21	294.80		3.48	5.99
ERROR	10	456.99	45.70	6.45**		
TOTAL	14	1636.21				

Cv = 12.00%

b** = Significant at 1%

ANALYSIS OF VARIANCE OF PLANT HEIGHT FOR 50 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	462.22	115.56		3.48	5.99
ERROR	10	1584.23	158.42	0.73^{ns}		
TOTAL	14	2046.45				

Cv = 14.3%

b = Non-significant

ANALYSIS OF VARIANCE OF PLANT HEIGHT FOR 60 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	903.73	225.93		3.48	5.99
ERROR	10	2407.25	240.73	0.94[ns]		
TOTAL	14	3310.97				

Cv = 15.84%

b = Non-significant

ANALYSIS OF VARIANCE OF PLANT HEIGHT FOR 70 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	728.34	182.21		3.48	5.99
ERROR	10	6278.79	627.70	0.29[ns]		
TOTAL	14	7005.12				

Cv = 25.23%

b = Non-significant

ANALYSIS OF VARIANCE OF PLANT HEIGHT FOR 80 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABULAR F 5%	1%
TREATMENT	4	959.13	239.78		3.48	5.99
ERROR	10	7837.44	783.74	0.31^{ns}		
TOTAL	14	8796.59				

Cv = 24.46%

b = Non-significant

ANALYSIS OF VARIANCE OF PLANT HEIGHT FOR 90 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABULAR F 5%	1%
TREATMENT	4	936.99	234.25		3.48	5.99
ERROR	10	5096.22	509.62	-68.94^{ns}		
TOTAL	14	6033.22				

Cv = 19.76%

b = Non-significant

TABLE 4.14

ANALYSIS OF VARIANCE OF WATER APPLIED FOR 10 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	642.41	160.60		3.48	5.99
ERROR	10	241.84	24.184	4.21*		
TOTAL	14	884.25				

Cv = 29.40%

b* = Significant

ANALYSIS OF VARIANCE OF WATER APPLIED FOR 20 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	922.62	230.63		3.48	5.99
ERROR	10	471.29	47.13	4.89*		
TOTAL	14	1393.91				

Cv = 41.43%

b* = Significant at 5%

ANALYSIS OF VARIANCE OF WATER APPLIED FOR 30 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	507.20	126.80		3.48	5.99
ERROR	10	9.38	0.94	135.12**		
TOTAL	14	516.67				

Cv = 16.49%

b** = Significant at 1%

ANALYSIS OF VARIANCE OF WATER APPLIED FOR 40 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	490.27	122.57		3.48	5.99
ERROR	10	3.40	0.34	306.34**		
TOTAL	14	493.67				

Cv = 10.01%

b** = Significant at 1%

ANALYSIS OF VARIANCE OF WATER APPLIED FOR 50 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	6907.00	1726.75		3.48	5.99
ERROR	10	6982.10	698.21	2.47^{ns}		
TOTAL	14	-75.07				

Cv = 175.9%

b = Mpm-significant

ANALYSIS OF VARIANCE FOR WATER APPLIED FOR 60 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	1095.29	273.82		3.48	5.99
ERROR	10	101.59	10.16	26.90**		
TOTAL	14	1196.88				

Cv 18.03%

b** Significant at 1%

ANALYSIS OF VARIANCE FOR WATER APPLIED FOR 70 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	1421.75	355.44		3.48	5.99
ERROR	10	14.40	1.44	246.9**		
TOTAL	14	1436.15				

Cv = 6.28%

b** = Significant at 1%

ANALYSIS OF VARIANCE FOR WATER APPLIED FOR 80 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	1040.92	260.23		3.48	5.99
ERROR	10	-8462.67	846.26	0.31^{ns}		
TOTAL	14	-7421.70				

Cv = 118.93%

b = Non-significant

ANALYSIS OF VARIANCE OF WATER APPLIED FOR 90 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	812.63	210.63		3.48	5.99
ERROR	10	-8073.13	807.31	0.26^{ns}		
TOTAL	14	-7230.50				

Cv = 117.1%

b = Non-significant

TABLE 4.15

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 20 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	45.02	11.26		3.48	5.99
ERROR	10	47.13	4.71	2.39^{ns}		
TOTAL	14	92.15				

Cv = 9.19%

b = Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 30 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	48.45	12.113		3.48	5.99
ERROR	10	50.51	5.051	2.4^{ns}		
TOTAL	14	98.96				

Cv = 9.25%

b = Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 40 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	23.65	7.89		3.48	5.99
ERROR	10	54.27	5.43	1.45^{ns}		
TOTAL	14	77.92				

Cv = 86%

b = Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 50 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	-10900.80	2725.2		3.48	5.99
ERROR	10	10972.37	1097.24	2.48[ns]		
Total	14	71.60				

CV = 115.8%

b = Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 60 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	24.67	6.168		3.48	5.99
ERROR	10	77.33	2.733	2.26[ns]		
TOTAL	14	52.00				

Cv = 5.9%

b = Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 70 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	27.29	6.823		3.48	5.99
ERROR	10	7695.70	769.57	$8.86X10^{-3ns}$		
TOTAL	14	7722.99				

Cv = 99.9%

b Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 80 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABU-LAR F 5%	1%
TREATMENT	4	52.26	13.07		3.48	5.99
ERROR	10	57.32	5.732	2.28^{ns}		
TOTAL	14	109.39				

Cv 8.70%

b Non-significant

ANALYSIS OF VARIANCE OF STEM DIAMETER FOR 90 DAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COM-PUTED F	TABULAR F 5%	1%
TREATMENT	4	52.02	13.01		3.48	5.99
ERROR	10	132.3	13.23	0.98^{ns}		
TOTAL	14	184.28				

Cv = 13.26%

b = Non-significant

TABLE 4.16

SOIL PHYSICAL PROPERTY FOR 45 DAP

DEPTH (cm)	BULK DENSITY (g/cm^3)	MOISTURE CONTENT %	POROSITY %	SOIL TEXTURE
0-20	3.325	0.759	0.758	Sandy Loamy
20-40	3.293	1.724	1.701	"
40-60	3.246	3.373	3.089	"
60-80	3.218	4.110	3.952	"

SOIL PHYSICAL PROPERTY FOR 60 DAP

DEPTH (cm)	BULK DENSITY (g/cm^3)	MOISTURE CONTENT %	POROSITY %	SOIL TEXTURE
0-20	3.218	2.660	2.597	Sandy Loamy
20-40	3.195	2.846	2.771	
40-60	3.166	0.295	3.707	
60-80	3.166	3.815	3.680	

SOIL P|HYSICAL PROPERTY FOR 75 DAP

DEPTH (cm)	BULK DENSITY (g/cm^3)	MOISTURE CONTENT %	POROSITY %	SOIL TEXTURE
0-20	3.134	2.951	2.854	Sandy Loamy
20-40	3.134	4.390	4.193	
40-60	3.202	5.064	4.820	
60-80	3.134	2.655	2.588	

SOIL PHYSICAL PROPELRTY FOR 90 DAP

DEPTH (cm)	BULK DENSITY (g/cm^3)	MOISTURE CONTENT %	POROSITY %	SOIL TECTURE
0-20	3.257	0.939	1.390	Sandy Loamy
20-40	3.267	0.444	0.444	
40-60	3.335	1.604	1.596	
60-80	3.261	5.125	3.788	

TABLE 4.17

INFILTRATION RATE

TIME (min)	WATER LEVEL (cm)	READING (cm)	DIFFEREN-CE (cm)	ACCUMU-LATIVE INFIL-TRATION (cm)	AVERAGE INFIL-TRATION (cm/hr)
00	11.00	11.00	-	-	-
50	11.00	4.50	6.50	6.50	78.00
10	11.00	4.70	6.30	12.90	76.80
15	11.00	4.70	6.30	19.10	76.40
20	11.00	4.90	6.90	26.00	76.00
25	11.00	5.10	5.90	31.90	75.00
30	11.00	5.10	5.90	37.80	75.60
35	11.00	5.20	5.80	43.60	74.74
40	11.00	5.40	5.60	49.20	73.80

TIME (min)	WATER LEVEL (cm)	READING (cm)	DIFFEREN-CE (cm)	ACCUMU-LATIVE INFIL-TRATION (cm)	AVERAGE INFIL-TRATION (cm/hr)
45	11.00	6.00	5.00	54.20	70.70
50	11.00	6.30	4.70	58.90	70.68

APPENDIX B

Steps to compute analysis of variance are:

Step 1: Construct an appropriate outline of the analysis of variance of data from plot sampling based on the experimental design used. For instance the form of the analysis of variance is shown in Chapter four.

Step 2: Construct the replication treatment table of total (RT) and compute the replication total ®, the treatment totals (T) and the grand total (G).

Step 3: Compute the correction factor and the sum of squares.

i. $cf = G^2/Trs$

ii. Total $ss = \sum x^2 - cf$

iii. Replication $ss = \sum R^2/ts - cf$

iv. Treatment $ss = \sum T^2 - cf$

v. Experimental errors $= \sum(RT)^2/S - cf - SSR - SST$

vi. Sampling errors ss = Total ss – (sum of other ss).

Step 4: For each source of variation, compute the mean square by dividing the ss by its corresponding degree of freedom.

i. Replication ms = Replication ss/r-1

vii. Treatment ms = Total ss/t-1

viii. Sampling error ms = sampling error ss/(r-1)(t-1)

ix. Sampling error ms = sampling error ss/tr(s-1)

Step 5: To test the significance of the treatment effect, compute the F value as F = treatment ms/experimental error ms and compare it with the tabular F values (appendix C) with F_2 = (t-1) and F_2 = (r-1)(t-1) (Page 635 by Bomez K. Aola).

Step 6: Enter all values obtained in step 2 to step 5 in the analysis of variance outline of step 1.

Step 7: For mean comparison, compute the standard error of difference between the treatment as Sd = $\sqrt{2(ms^2)/rs}$ where ms^2 is the experimental error ms in the analysis of variance.

Step 8: Compute the grand mean and co-efficient of variance Cr as follows:

Grand mean = G/n

Cr = $\sqrt{\text{error ms}}$ x 100/Grand mean.

The Cr indicates the degree of precision with which the treatments are compared as is a good index of the reliability of the experiment.

APPENDIX C

ETO was determined with a quantified form of the blaney-morrin-Nigeria model as expressed by Duru (1984) as

$$ETO = rf\,[(0.45T + 8)(520 - R^{1.37})]/100$$

Where

ETO = reference evapotranspiration in mm per day

rf = monthly max radiation

Annual max radiation

T = TLc mean temperature in °C

R = is the mean relative humidity in %.

N.B rf, T and R are meterological data based on localities in which the crop (maize) was planted.

APPENDIX D

1999

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RAIN-FALL (mm)	0.0	0.0	0.0	67.1	213.2	75.5	239.7	145.5	153.7	105.0	0.0	0.0
CUMMU-LATIVE TOTAL (mm)	0.0	0.0	0.0	67.1	270.3	345.8	585.5	631.0	784.7	887.7	887.7	887.7
MAX TEMP^{O}c	40	39	41	34	34	32	27	28	31	34	36	35
MIN TEMP^{O}C	24	24	27	24	27	24	24	24	23	24	17	16
R/TT %	65	29	58	82	85	77	88	86	84	77	73	62

Appendix E.

Extra Terrestrial Radiation (Ra) expressed in equivalent evaporation in mm/day

Northern Hemisphere													Southern Hemisphere											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Lat	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	De
3.8	6.1	9.4	12.7	15.8	17.1	16.4	14.1	10.9	7.4	4.5	3.2	50°	17.5	14.7	10.9	7.0	4.2	3.1	3.5	5.5	8.9	12.9	16.5	18.
4.3	6.6	9.8	13.0	15.9	17.2	16.5	14.3	11.2	7.8	5.0	3.7	48	17.6	14.9	11.2	7.5	4.7	3.5	4.0	6.0	9.3	13.2	16.6	18.
4.9	7.1	10.2	13.3	16.0	17.2	16.6	14.5	11.5	8.3	5.5	4.3	46	17.7	15.1	11.5	7.9	5.2	4.0	4.4	6.5	9.7	13.4	16.7	18.
5.3	7.6	10.6	13.7	16.1	17.2	16.6	14.7	11.9	8.7	6.0	4.7	44	17.8	15.3	11.9	8.4	5.7	4.4	4.9	6.9	10.2	13.7	16.7	18.
5.9	8.1	11.0	14.0	16.2	17.3	16.7	15.0	12.2	9.1	6.5	5.2	42	17.8	15.5	12.2	8.8	6.1	4.9	5.4	7.4	10.6	14.0	16.8	18.
6.4	8.6	11.4	14.3	16.4	17.3	16.7	15.2	12.5	9.6	7.0	5.7	40	17.9	15.7	12.5	9.2	6.6	5.3	5.9	7.9	11.0	14.2	16.9	18
6.9	9.0	11.8	14.5	16.4	17.2	16.7	15.3	12.8	10.0	7.5	6.1	38	17.9	15.8	12.8	9.6	7.1	5.8	6.3	8.3	11.4	14.4	17.0	18
7.4	9.4	12.1	14.7	16.4	17.2	16.7	15.4	13.1	10.6	8.0	6.6	36	17.9	16.0	13.2	10.1	7.5	6.3	6.8	8.8	11.7	14.6	17.0	18
7.9	9.8	12.4	14.8	16.5	17.1	16.8	15.5	13.4	10.8	8.5	7.2	34	17.8	16.1	13.5	10.5	8.0	6.8	7.2	9.2	12.0	14.9	17.1	18
8.3	10.2	12.8	15.0	16.5	17.0	16.8	15.6	13.6	11.2	9.0	7.8	32	17.8	16.2	13.8	10.9	8.5	7.3	7.7	9.6	12.4	15.1	17.2	18
8.8	10.7	13.1	15.2	16.5	17.0	16.8*	15.7	13.9	11.6	9.5	8.3	30	17.8	16.4	14.0	11.3	8.9	7.8	8.1	10.1	12.7	15.3	17.3	18
9.3	11.1	13.4	15.3	16.5	16.8	16.7	15.7	14.1	12.0	9.9	8.8	28	17.7	16.4	14.3	11.6	9.3	8.2	8.6	10.4	13.0	15.4	17.2	17
9.8	11.5	13.7	15.3	16.4	16.7	16.6	15.7	14.3	12.3	10.3	9.3	26	17.6	16.4	14.4	12.0	9.7	8.7	9.1	10.9	13.2	15.5	17.2	17
10.2	11.9	13.9	15.4	16.4	16.6	16.5	15.8	14.5	12.6	10.7	9.7	24	17.5	16.5	14.6	12.3	10.2	9.1	9.5	11.2	13.4	15.6	17.1	17
10.7	12.3	14.2	15.5	16.3	16.4	16.4	15.8	14.6	13.0	11.1	10.2	22	17.4	16.5	14.8	12.6	10.6	9.6	10.0	11.6	13.7	15.7	17.0	17
11.2	12.7	14.4	15.6	16.3	16.4	16.3	15.9	14.8	13.3	11.6	10.7	20	17.3	16.5	15.0	13.0	11.0	10.0	10.4	12.0	13.9	15.8	17.0	17
11.6	13.0	14.6	15.6	16.1	16.1	16.1	15.8	14.9	13.6	12.0	11.1	18	17.1	16.5	15.1	13.2	11.4	10.4	10.8	12.3	14.1	15.8	16.8	17
12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6	16	16.9	16.4	15.2	13.5	11.7	10.8	11.2	12.6	14.3	15.8	16.7	16
12.4	13.6	14.9	15.7	15.8	15.7	15.7	15.7	15.1	14.1	12.8	12.0	14	16.7	16.4	15.3	13.7	12.1	11.2	11.6	12.9	14.5	15.8	16.5	16
12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5	12	16.6	16.3	15.4	14.0	12.5	11.6	12.0	13.2	14.7	15.8	16.4	16
13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9	10	16.4	16.3	15.5	14.2	12.8	12.0	12.4	13.5	14.8	15.9	16.2	16
13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8·	13.9	13.3	8	16.1	16.1	15.5	14.4	13.1	12.4	12.7	13.7	14.9	15.8	16.0	16
13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7	6	15.8	16.0	15.6	14.7	13.4	12.8	13.1	14.0	15.0	15.7	15.8	15
14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1	4	15.5	15.8	15.6	14.9	13.8	13.2	13.4	14.3	15.1	15.6	15.5	15
14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4	2	15.3	15.7	15.7	15.1	14.1	13.5	13.7	14.5	15.2	15.5	15.3	15
15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8	0	15.0	15.5	15.7	15.3	14 4	13.9	14.1	14.8	15.3	15.4	15.1	14

ABSTRACT

To determine evapotranspiration coefficients for maize, experiment was carried out in the green house environment at the National Cereal Research Institute in Bida Local Government Area of Niger State. DMR-YE maize variety (yellow-maize) was planted in cylindrical containers of 400 mm internal diameter and 720 mm depth.

The water levels in the containers ranged from 100 mm to 650 mm from the soil surface, the parameters monitored during the period of experiment (September to December 1999) include leaf area, plant height, water use, stem diameter, stover weight and grain yield.

Cummulative water use for 90 days after planting were 621.9 mm, 4811.4 mm, 406.9 mm, 338.4 mm and 280.9 mm corresponding to water table depths of 300 mm, 450 mm, 600 mm, 650 mm and free drainage respectively. Crop coefficients values (K_c) obtained ranged between 0.42 to 1.12, grain yield at water table depths of 300 mm, 450 mm, 600 mm and 650 mm were 52.39×10^{-1} kg/m^2, 3.62×10^{-1} kg/m^2, 2.90×10^{-1} kg/m^2 and 2.33×10^{-1} kg/m^2 respectively. The experiment established that for successful maizse production under shallow water table condition, water table depth for soil (sandy-loamy) at 300 mm and 450 mm can be considered optimum (K_c = 1.12).

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