THE INFLUENCE OF DRIP IRRIGATION FREQUENCY AND MULCHING ON THE SOIL PHYSICAL PROPERTIES AND YIELD IN OKRA. *(Abelmoschus esculentus)*

BY

OMOTAYO ADEOLA ADESUA

SSC/12/0480

A THESIS SUBMITTED TO

THE FACULTY OF AGRICULTURE, DEPARTMENT OF SOIL SCIENCE AND LAND RESOURCE MANAGEMENT, FEDERAL UNIVERSITY OYE-EKITI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF AGRICULTURE (B. Agric.) IN SOIL SCIENCE

FEDERAL UNIVERIESTY OYE-EKITI NIGERIA

NOVEMBER, 2017

CERTIFICATION

This is to certify that this is an original and independent research project carried out by OMOTAYO A.A (SSC/12/0480) in the Department of Soil Science and Land Resources Management in partial fulfillment for the award of Bachelor of Agriculture (B.Agric.) in Soil Science, Federal University Oye-Ekiti.

....

Dr. K. S. Ogunleye

Supervisor

Date : 15/01/2018

....

Prof. S.O. Shittu

Head of Department

Date : 29/01/18

DEDICATION

This project work is dedicated to the Lord God Almighty, the author and the finisher of this work.

TABLE OF CONTENTS

Cover page	
Title page	i
Certification	ii
Dedication	iii
Table of contents	iv
Abstract	vi
Acknowledgement	vii
List of figures	viii
List of tables	ix

CHAPTER ONE

1.0	INTRODUCTION	1
1.1	Objectives	3
1.1.1	Overall objective	3
1.1.2	Specific objectives	3
1.2	Justification	3
1.3	Hypothesis	4

CHAPTER TWO

2.0	LITERATURE REVIEW	5
2.1	Origin and Geographic Distribution of okra	5
2.2	Ecology and Seasonal Growth	6
2.3	Propagation and Planting	7
2.4	Integrated Management	7
2.5	Irrigation Agriculture	8
2.5.1	Irrigation Systems	8
2.5.2	Advantages of drip irrigation	9
2.6	Crop Water Requirement	9
2.7	Soil Physical Properties	10
2.8	Effect of drip irrigation application rate on soil physical properties	11
2.9	Mulching	11
2.9.1	Effects of Mulching on physical properties, growth and yield	12

CHAPTER THREE

3.0 MATERIALS AND METHODS 14
3.1 Description of Experimental Site 14
3.2 Experimental Design and Treatments 14
3.3 Land preparation, Field Layout and Installation of the Drip Irrigation System 14
3.4 Planting and Field Management 15
3.5 Soil Sampling and Analysis 16
3.6 Soil water content 16
3.7 Bulk density 17
3.8 Saturated hydraulic conductivity, (Ksat) 17
3.9 Statistical Analysis 17

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION 18
4.1 Soil physicochemical properties of the study area 18
4.2 Effect of drip irrigation frequency and mulching material on okra plant height 19
4.3 Effect of drip irrigation frequency and mulching material on number of leaves of okra 21
4.4 Effect of drip irrigation frequency and mulching materials on yield and yield attributes of okra. 23
4.5 Correlation among growth parameters, yield and yield components 25
4.6 Effect of drip irrigation on the selected soil physical properties 26
4.7 Effect of mulching on some selected soil physical properties 27
4.8 Effect of irrigation and mulching on some physical properties 28

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION 30
5.1 Conclusion 30
5.2 Recommendation 31
REFERENCES 32
APPENDIX 35

ABSTRACT

Several irrigation systems or methods have been use by many people to efficiently provide water for crop productivity. Drip irrigation system has been a best method so far, supplying water to plant, maximizing water usage, it tends to be cost effective and reduces stress. The field experiment was conducted between January 2017 and March 2017 at the Teaching and Research Farm, Federal University Oye-Ekiti (Ikole Campus). The experiment design used entail; two factorial laid in a randomized complete block design (RCBD) with four replications. Irrigation constituted the main factor at three levels: (daily, twice a week and thrice a week designate-d as F_1, F_2, F_3 respectively), while the sub-plot was mulching which include; (plastic mulch, natural mulch and no mulch designated as M_1, M_2, M_3) which in total give nine treatment combinations and 36 plots in total. Soil samples were randomly collected from 0 – 15 cm soil depth from three representative locations and were mixed to obtain a composite sample to determine some selected soil physiochemical properties including soil pH, K, Na, Mg, Ca, total organic carbon (TOC), total nitrogen (TN) and available phosphorus and soil texture, particles size, bulk density, soil water content, saturated hydraulic -conductivity. Data derived were subjected to descriptive statistics and analysis of variance (ANOVA) and means were separated by Tukey Honest Test at 5% level of probability. The Pearson correlation coefficient gave some important information on the growth parameters, yield and yield components.

ACKNOWLEDGEMENT

My appreciation and gratitude goes to the Almighty God, for his grace over my life and for helping me through in this project work.

I am immensely grateful to my supervisor, Dr. K.S. Ogunleye whose contribution and his spirit of endurance made this project a successful one, I will forever be grateful for his patience, love, kindness and fatherly embracement. I pray that his life and family will always experience upliftment and the blessing of God.

I am happy for the kind of parents God gave to me for understanding, caring and support, Mr. Omotayo J.A and my amiable mother Mrs .S. Omotayo, as Yoruba do say (Abiyamo tooto), may God spare your life to eat the fruit of your labour.

Also, a say big thank you my lecturers at different levels of my study in the citadel of higher learning and to all the staff of the Faculty of Agricultural Sciences. I cannot mention all but God will surely bless you all in abundant.

My acknowledgment goes to my love, friends, colleagues and siblings; Akomolafe Omotola, Toyin, Ezekiel, Isaac, Ayomide, Iyanu, Ewoh, Kaycee, Jumoke, Isiaq, Omotayo Taiwo and Kehinde, Idowu, Paul and Silas, Mummy Abbey and Others, thanks for support, May God reward you all.

To my project mates in persons of Bello Oluwatoyin Zainab and Corper Marachi, for their assistance and support during and after the project work. We shall succeed together in life.

Also to my loved ones so innumerable to mention, no amount of words can express my gratitude to you all, May God bless you all.

LIST OF FIGURES

Fig 1	Field layout	15
Fig 2	Interactive effect of drip irrigation frequency and mulching materials on okra plant height	20
Fig 3	Interactive effect of drip irrigation frequency and mulching materials on okra plant height	22

LIST OF TABLES

Table 1	Physicochemical properties of the study area	18
Table 2	Effect of drip irrigation frequency and mulching material on okra plant height	19
Table 3	Effect of drip irrigation frequency and mulching material on number of leaves of okra	21
Table 4	Effect of drip irrigation frequency and mulching materials on yield and yield attributes of okra	24
Table 5	Correlation among growth parameters, yield and yield components	25
Table 6	Effect of drip irrigation on soil physical properties	26
Table 7	Effect of mulching on soil physical properties Mulching	27
Table 8	Interaction table of irrigation and mulching methods affecting soil physical properties.	29

CHAPTER ONE

1.0 INTRODUCTION

Okra (Almoschus esculentus L.) belongs to the family of Malvaceae. It is an important vegetable crop in Nigeria, and is grown extensively, throughout the country as summer crop. The young tender pods are used as fresh or as dry powder in soup and stew. Okra is an annual herb and vegetable crop grown throughout the tropical and subtropical parts of the world either as the sole crop or intercrop with maize or another crop (Emuh et al., 2006).

As a result of the need to boost food supply for the populace, emphasis has been placed on irrigated agriculture. Despite the simplicity of the surface irrigation systems, efficiency use of water has become increasingly important and alternative water application methods such as the drip irrigation system has been advocated for ensuring the best use of water for agriculture and improving irrigation efficiency. Thus, the trend has been towards conversion from surface to drip irrigation (Sezen et al., 2007). Scheduling water application is very critical to make efficient use of drip irrigation system as excessive irrigation decreases yield while insufficient irrigation causes water stress and reduces production. On the other hand, the intensity of the operation requires that the soil water supply be kept at the optimal level to maximize returns to the farmer (Sezen et al., 2007). Several experiments have shown positive responses in some crops to different drip irrigation frequency (Segal et al., 2000; Sharmasarkar et al. 2001), however, there seems to be inconsistency as to what frequency might be optimum for certain crops and under certain conditions. While Dalvi et al (1999) found that the maximum yield was obtained at every second day frequency, Wang et al (2006) found that reducing irrigation frequency from one day to a week resulted into significant reduction in potato yield while (Pitts et. al 1991) reported that two drip irrigation frequencies (three times per day, one time per day) had no effect on tomato yield.

The introduction of irrigation to the soil leads to fundamental changes in the physical properties and processes, such as placing stresses upon soil structure which affects the pore space, availability of water, nutrients and gaseous exchange (Hamblin, 1985) because irrigated soils experience rapid wetting and undergo a greater number of alternate wetting and drying cycles compared with rainfed agriculture (Currie, 2006). Evidence of soil structural decline, such as increased bulk density, under drip irrigation has been reported (Clark, 2004).

The high economic value of okra crops justified the modification to the producers, improved quality and extension of the growing season, producers of okra crops often used different mulching types to suppress weed or conservation of moisture near the root of the crop. Mulches affect not only the soil environment. However, the mulches change the plants environment depending on the properties of the mulches and the level of the physical contact between the mulch materials and the soil.

Mulching is the process or practice of covering the soil/ground to make more favorable condition for plant growth, development and efficient crop production. Mulch technical term means covering of soil, while natural mulches such as leaf, straw, dead leaves and compost have been used for centuries. During the last 60 years, the advent of synthetic materials has altered the method and benefit of mulching. The research as well as field data available on effects of different mulch types on okra growth performance make a vast volume of literature. It therefore prevent directs evaporation of moisture from the soil and thus limit the water losses and soil erosion over the surface. The suppression of evaporation also has a supplementary effects, it prevent the rise of water containing salt which is important in countries with high salt content water sources. Among other advantages of mulching are: prevention of direct evaporation of moisture from the soil and thus limits the water losses and conserves moisture, facilitates fertilizer placement and reduce the loss of plant nutrient through leaching and provides a barrier to soil pathogens.

The use of sawdust, polythene, straw mulches for dry season vegetable production in the research farm increases the soil temperature, conserves soil moisture. In this manner, it plays a positive role in the water conservation.

The objective of this research work is to evaluate the influence of drip irrigation and mulching on the soil physical properties and the water use efficiency of the okra.

1.1 Objectives

1.1.1 Overall objective

The overall aim of the study is to evaluate the influence of drip irrigation and mulching on the soil physical properties and water use efficiency of okra.

1.1.2 Specific objectives

The specific objectives of the study are to:

i. Evaluate the effects of different drip irrigation regimes and mulch types on the soil physical properties of the soil grown to okra.

ii. Evaluate the water use efficiency of okra plants in response to the different drip irrigation regimes and mulch types.

iii. Determine the correlation between the soil hydro-physical properties and yield of okra.

1.2 Justification

Efficient use of water by irrigation is becoming important and alternative methods such as drip and sprinkler may contribute substantially to the best use of water for agriculture and improving irrigation efficiency because of decrease in rainfall being experienced in different parts of the world. Mulching on the other hand has its role in maintaining the soil structure and reduces direct evaporation of moisture from the soil and thus limits the water losses and conserves moisture as most soil are impoverished due to evaporation of moisture from the soil especially during the dry season. Also, given the fact that okra is a short duration crop, there is a high prospect of producing okra all year round. However, information on influence of drip irrigation and mulching on the soil physical properties and water use efficiency is scarce especially in Ikole Ekiti, south western Nigeria.

1.3 Hypothesis

Ho: Drip irrigation frequency and mulching had no influence on the soil physical properties and yield in okra.

Ha: Drip irrigation frequency and mulching had influences on the soil physical properties and yield in okra.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Geographic Distribution of okra

Okra plant or lady's finger was previously included in the genus Moicus. Later it was designated to Abelmoschus, which is distinguished from the genus Hibicus. (Aladele et al 2008). Abelmoschus was subsequently proposed to be raised to the rank of distinct genus by Medilues in (1787). Okra originated somewhere around the Ethiopia and was cultivated by the ancient Egyptians by the 12th century BC. Its cultivation spread throughout Middle East and North Africa Tindall (1983), Lamount (1999). Okra is grown in many parts of the world, especially in tropical and subtropical countries Arapitses, (2007), Saiffellah and Rabbani, (2009). This crop can be grown as a large commercial farm or as a garden crop Rubatzky and Yamaguchi, (1997). Okra crop can be grown commercially in many countries such as India, Japan, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Myanmar, Malaysia, Thailand, Brazil, Ethiopia, Cyprus and in the Southern United States. (Purseylove, 1887). (Benjawan et al., 2007), (Ghurishi 2007). Okra is found all around the world from equatorial areas to Mediterians Sea which is considered as the center of diversity. The spread of the other species is the result of their introduction to Africa and America Qhiereshi (2007), Aladeye et al., (2008). There are two hypotheses concerning the geographical origin of A. esculentus. Some scientist argue that one putative ancestors (A. tuberculatus) is native from Northern India, suggesting that the species originated from this geographical area on the bases of ancient cultivation in East Africa and the presence of the other putative ancestor (A. ficulneous) other suggest that the area of domestication is Ethiopia or North Egypt, but no definite proof is available today Department of Biotechnology, (2007). Abelmoschus species occurs in the world including as A. moschus, A. manihot, A. esculentus, A. tuberculatus, A.

filculneous, A. Crinilus, and A. angulosus Chorrier (1984). The three cultivation species which are sometimes found in all tropical, subtropical and warm temperature regions of the world. The species A. moschus has a wide geographical distribution in India, Southern China, Indonesia, Papcia, New Guinea, Australia, Central and West Africa. The species A. manihot subs P. Manihot is cultivated mainly in the East Asia, but also in the India sub-continent and Northern Australia. It is less frequently found in America and tropical Africa Cheva Lier (1940). The wild species A. tuberculatus related to A. esculentus, is endemic to the medium altitudes hilly areas in India IBPGR, (1991). The wild species A. ficulnoues is found in a vast geographical area stretching from Africa to Asia and Australia. It flourishes in tropical's area of low altitude with a long dry season, i.e. desert regions of Sahalian Africa (Niger) Madagascar, East Africa, India, Indonesia, Malaysia and Northern Australia Lamount (1999). The two wild species A. crinitus and A. angulosus are exclusively Asian origin. There are differentiated by their ecology. A crinitus grows at low altitude in regions with a marked dry season, being (China, India, Pakistan and Philippines). A. angulosus grows at altitude between 750 and 2000m in Pakistan, India, Sri Lanka, Indonesia Charrier (1984) and IBPGR (1991).

2.2 Ecology and Seasonal Growth

Okra needs temperature above 20°C for normal growth and development, Lamount, (1999), Abel El Kader et al. (2010). Germination percentage and speed of emergence are optimum at 30°C - 35°C Akande et al., (2003). Flower initiation and flowering are delayed with an increase in temperature and number (positive correlation between temperature and number of vegetables nodes) Lamount, (1999), Abel El Kader et al., (2010). Abelmoschus species is a short-day plant but its wide geographical distribution (Up to latitude of 35°C - 40°C) indicates that cultivars differ markedly in sensitivity. Most tropical cultivars show quantitative short day responses, but qualitative responses also occur. Okra is a long day crop. This explains why flowering of local cultivars of common okra is only qualitatively affected by day length in the coasted areas of the latitude (10°N). One can occasionally observe very tall non-flowering plants of common okra due to a qualitative response. Okra tolerates poor soil, but prefers well-drained sandy loam, with the pH 6-7 and high content of organic matter. Okra requires a moderate rainfall of 80-100cm in well distributed to produce its young edibles fruits over a relatives long period. An average temperature of 20^0 - 30°C is considered optimum for grazing, flowering and fruiting Akinyele and Temikotan, (2007), Dada and Fayinminnu, (2010).

2.3 Propagation and Planting

Most farmers harvest seed from their own local cultivar or rather heterogeneous landrace Moekchantuk and Kumar (2004). The easiest way to keep the seed is to leave it in the pods. Seed weight varies from 30 to 80 g per 1000 seeds. To soften the hard seed coat, the seed is often soaked in water or chemicals prior to sowing. The seed is usually dibbled directly in the field (2-3 seeds per hole). Optimum plant densities are in the range of 50,000 - 60,000 plants ha-1 Olasotan (2001). Emergence is within one week. When the plants are about 10 cm tall, they are thinned to one plant per hole. Germination and initial growth are improved greatly by cultural practices that lower soil temperature, e.g. mulching, watering before the hottest part of the day', and sowing on ridge sides least exposed to direct sunlight Splittstoesser (1984) and Doijode (2001).

2.4 Integrated Management

Commercial okra growers usually practice sole cropping, and prefer the early, homogeneous, introduced cultivars. In traditional agriculture, farmers grow their okra landraces in home gardens or in fields with other food crops Rashid et al. (2002). In West and Central Africa the landraces often consist of a mixture of Abelmoschus esculentus and Abelmoschus caillei, the former being predominant in dry climates, the latter in humid climates Dahire-Binsu et al. (2009). The uptake of minerals is rather high. Indicative figures for total nutrient uptake per hectare of a crop with a fruit yield of about 10t ha^{-1} are 100 kg N, 10 kg P, 60 kg K, 80 kg Ca and 40 kg Mg (Kumar et al., 2010). Under humid tropical conditions a full grown crop consumes about 8 mm of water per day. A ration crop flowers soon after cutting, but usually results in poor quality fruit with a high percentage of bent fruits Purseglove (1987), Anant & Manohar (2001).

2.5 Irrigation Agriculture

Irrigation aims at complementing the water available from natural sources such as rainfall, dew, flood and ground water that seep into root zone. It is useful in many parts of western Africa, where natural source is inadequate for effective crop germination and production (Fasina et al, 2008)

2.5.1 Irrigation Systems

Surface irrigation is the type of water application techniques where water is applied and distributed over soil surface area by gravity. It is by far the most common form of irrigation throughout the world and has been practiced in many years. This is also known as flood irrigation, where water distribution is uncontrolled and therefore, inherently inefficient; it is mostly in Northern part of Nigeria where rainfall is not prevalent (FAO, 1999).

Subsurface irrigation is irrigation of crops through buried plastic tubes containing embedded emitters located at regular spacing (drippers). It is mostly used for the irrigation of annual row and field crops, but it can be used for any crops. In other parts of the world such as it is real, it is widely used for irrigation of permanent crops providing maximum yields and optimal water use efficiency (Camp, 1998). Sprinkler irrigation is a method of applying irrigation water which is similar to rainfall. Water is distributed through system of pipes usually by pumping, which is then sprayed through the air sprinklers so as to break up small drops which fall to the ground. The pump supply system, sprinklers on operating conditions must be designed to enable a uniform application (FAO, 1988).

Drip irrigation on the other hand is a highly efficient method for improved water productivity of dry farming. It controls the amount of water to be applied. This system facilitates increased water use efficiency, integrated application of water and nutrients, promote the sophistication of monitoring, automation and control of irrigation (Aruleba, 2011).

2.5.2 Advantages of drip irrigation

If the system is properly designed, installed, and managed, drip irrigation may help to achieve water conservation by reducing evaporation and deep drainage. Compared to other types of irrigation systems, ware can be more precisely applied to the plant roots. In addition, drip irrigation can eliminate many diseases that are spread through irrigation water. Drip irrigation is adaptable to any farmable slope and is suitable for most soils (Beat Stauffer, 2011).

2.6 Crop Water Requirement

The crop water need always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favourable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

2.8 Effect of drip irrigation application rate on soil physical properties

Some of the physical stresses or irrigation such as rapid wetting and prolonged wetness contributed to the degradation of soil. The alternate wetting and drying cycles due to irrigation modifies the soil matrix and hence influence soil physical and hydrological properties which influences crop growth and yield (Cameria et al., 2003). Drip irrigation also places physical stress upon soil structure, which may affect bulk density, saturated hydraulic conductivity, soil water availability and okra functioning. Hence, it influences soil moisture regime, water root distribution around the emitter, amount of water percolating on the root zone and the amount of water uptake by plant root (Assouline, 2002). Ultimately, the study of the impact of drip irrigation is imperative on monitoring soil physical properties to ensure sustainable production. Drip irrigation leading to aggregate coalescence which is a soil hardening process whereby the cementing of aggregates leads to increase in soil bulk density (Cockroft and Olsen, 2000).

2.9 Mulching

Mulching is the process or practice of covering the soil/ground to make more favorable condition for plant growths, development and efficient crop production. Mulch technical term means covering of soil, while natural mulches such as leaf, stray, dead leaves and compost have been used for centuries, during the last 60 years the advent of synthetic materials has altered the method and benefit of mulching. Mulching therefore prevent directs evaporation of moisture from the soil and thus limit the water losses and soil erosion over the surface. The suppression of evaporation also has a supplementary effects, it prevent the rise of water containing salt which is important in countries with high salt content water sources.

Advantages of Mulching

- It prevents the direct evaporations of moisture from the soil and thus limits the water losses and conserves moisture.
- Mulch can facilitate fertilizer placement and reduce the loss of plant nutrient through hatching.
- Mulching can provide a barrier to soil pathogens.

2.9.1 Effects of Mulching on physical properties, growth and yield

The use of plastic mulch helps conserving water by reducing evaporation from soil surface, controlling weed growth and reducing soil compaction. According to Ramakrishna et al. (2006), evaporation from the soil accounts for 25-50% of the total quantity of water used. Ramakrishna et al (2006), Wang et al (2009) and Kumar and Lal (2012) also indicated that the main advantage of using plastic mulch is to retain soil moisture, which ultimately leads to improved crop growth. Earlier researchers indicated that improvement in growth characters as a result of using mulches may be due to the enhancement in photosynthesis and other metabolic activities (Bhatt et al (2011); Parmar et al. (2013). Higher soil moisture content and soil temperature under mulch improves microclimate leading to early growth and development, which advances the flowering. Similar observation was also reported by Igbal et al. (2009) in hot pepper, Singh and Kamal (2012) in tomato and Parmar et al. (2013) in watermelon. These same researchers indicated that plants under mulch produced larger fruit and had higher yield per plant because of the better plant growth due to favorable hydro-thermal regime of soil and complete weed free environment. They also mentioned that the extended retention of moisture and availability of moisture also led to a higher uptake of nutrients of proper plant growth and development of plants, which resulted in higher growth of plants as compared to control. Sharma et al (1990), Ogban et al (2008), Mamkagh (2009) reported that higher moisture content increases root proliferation and thus enhances availability of nutrients to crop roots. All these factors led to the increase in the yield of the plants they worked on compared to the control.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Experimental Site

The field experiment was conducted between January 2017 and March 2017 at the Teaching and Research Farm, Federal University Oye-Ekiti. (Ikole Campus) It has a humid tropical climate characterized by distinct dry and wet seasons with moderate mean annual rainfall of about 1367.7 mm while temperature almost uniform throughout the year with little deviations from means 27^0C. According to the cropping history of the land; the place has never been under irrigation prior to this study.

3.2 Experimental Design and Treatments

The experiment was a two factorial laid in a randomized complete block design (RCBD) and four replications. Irrigation constituted the main factor at three levels: daily, twice a week and thrice a week designated as F_1, F_2, F_3 respectively, while the sub-plot was mulching constituted by plastic mulch, natural mulch and no mulch designated as M_1, M_2, M_3 respectively giving nine treatment combinations. There was a total of 36 plots.

3.3 Land preparation, Field Layout and Installation of the Drip Irrigation System

The experimental site was prepared manually. The land was properly cleared and unburied grasses were properly removed to ensure a clean field. The drip irrigation systems consisted of a 3000L tank, 25mm diameter main pipe and sub mains, end plugs, T-joint plugs, rubber hose, gum, gate valves, lateral cum drippers, pipe nipples, etc. The main line delivered water from the tank to the sub mains and sub mains into the drip lines, while the emitters delivered water to the field at a rate of 4 L h^{-1}. The field layout is shown in Fig. 1.

3.4 Planting and Field Management

Planting of the okra was done on the 8th of February 2017, on the prepared plots. Two seeds were planted at a spacing of 90 x 30cm. The field was adequately irrigated for crop emergence and establishment. After crop establishment, both irrigation and mulching were imposed. The mulching treatments used were plastic mulch and natural mulch. Weed control was done manually weekly.

REP 1	REP 2	REP 3	REP 4
F_1M_1 Daily irrigation + Plastic mulch	F_2M_2 Twice irrigation + Natural Mulch	F_3M_3 Thrice Irrigation + No mulch	F_1M_1 Daily irrigation + Plastic mulch
F_1M_2 Twice irrigation + Natural mulch	F_2M_3 Twice irrigation + No Mulch	F_3M_1 Thrice irrigation + Plastic mulch	F_1M_2 Twice irrigation + Natural mulch
F_1M_3 Thrice Irrigation + No mulch	F_2M_1 Twice Irrigation + Plastic mulch	F_3M_2 Thrice irrigation + Natural Mulch	F_1M_3 Thrice Irrigation + No mulch
F_2M_2 Twice irrigation + Natural Mulch	F_3M_3 Thrice Irrigation + No mulch	F_1M_1 Daily irrigation + Plastic mulch	F_2M_2 Twice irrigation + Natural Mulch
F_2M_3 Twice irrigation + No Mulch	F_3M_1 Thrice irrigation + Plastic mulch	F_1M_2 Twice irrigation + Natural mulch	F_2M_3 Twice irrigation + No Mulch
F_2M_1 Twice Irrigation + Plastic mulch	F_3M_2 Thrice irrigation + Natural Mulch	F_1M_3 Thrice Irrigation + No mulch	F_2M_1 Twice Irrigation + Plastic mulch
F_3M_3 Thrice Irrigation + No mulch	F_1M_1 Daily irrigation + Plastic mulch	F_2M_2 Twice irrigation + Natural Mulch	F_3M_3 Thrice Irrigation + No mulch
F_3M_1 Thrice irrigation + Plastic mulch	F_1M_2 Twice irrigation + Natural mulch	F_2M_3 Twice irrigation + No Mulch	F_3M_1 Thrice irrigation + Plastic mulch
F_3M_2 Thrice irrigation + Natural Mulch	F_1M_3 Thrice Irrigation + No mulch	F_2M_1 Twice Irrigation + Plastic mulch	F_3M_2 Thrice irrigation + Natural Mulch

Figure 1: Field layout showing the different treatment combinations

3.5 Soil Sampling and Analysis

Prior to planting, soil samples were randomly collected from 0 – 15 cm soil depth from three representative locations and were mixed to obtain a composite sample, which were air-dried, ground with mortar and passed through a 2 mm sieve for the determination of soil physical and chemical properties including soil pH, K, Na, Mg, Ca, total organic carbon (TOC), total nitrogen (TN) and available phosphorus and soil texture. The soil pH was determined using the digital electrode pH meter. Bray-1 extractant was used to extract available P (Olsen and Sommers, 1982) while organic carbon and total N were determined by Walkey-Black (1934) oxidation and Kjeldahl digestion technique, respectively (Bremner and M ulvaney, 1982). Exchangeable K, Ca, Mg and Na were extracted using normal ammonium acetate. K, Ca and Na were determined using Flame Photometry while Mg was determined by Atomic Absorption Spectrophotometry (AAS, Perkins Elmer 2280 model). Effective cation exchangeable capacity (ECEC) was obtained by the sum of exchangeable K, Ca, Mg and Na. Particle size distribution was determined by hydrometer method of soil mechanical analysis as outlined by Bouyoucous (1981).

In addition, undisturbed soil samples were collected using core samplers made from metallic cylinders for the determination of bulk density, soil water content, saturated hydraulic conductivity as described below:

3.6 Soil water content

The soil moisture content was determined according to the equation:

$$\theta_g = \frac{W_{ws} - W_{ds}}{W_{ds}}$$

Where θ_g= gravimetric soil moisture $cm^3\,cm^{-3}$; W_{ws}= Weight of wet soil (g), W_{ds} =Weight of oven dried soil (g).

3.7 Bulk density

After obtaining the undisturbed samples were oven –dried at 105^{0}C for 48h and the weight of the dry soil was determined (Blake and Hartge, 1986).

$$BD = Ms/V$$

Where BD= bulk density (g/cm^3), Ms= weight of dry soil (g), V=volume of soil (cm^3).

3.8 Saturated hydraulic conductivity, (Ksat)

Soil saturated hydraulic conductivity was determined by the constant-head permeameter (Klute and Dirksen, 1986) on undisturbed soil samples collected in metal cylinders (of known volume) after saturation by capillarity in water bath for 48 hours. The determination of Ksat was performed by collecting and measuring the amount of water that percolates through the soil samples under a constant hydraulic head of about 3cm in the water column, according to the methodology described by EMBRAPA (2011). From the data, soil Ksat was calculated using the following equation:

$$Ksat = \frac{Q*L}{A*H*t}$$

Where Ksat is saturated hydraulic conductivity, mm hr^{-1}; Q is volume of water that flow through the soil column in a given time, cm^3; L is length of the soil column, cm; A is area the soil column, cm^2; t is time, h.

3.9 Statistical Analysis

Data collected were subjected to descriptive statistics and analysis of variance (ANOVA) and means were separated by Tukey Honest Test at 5% level of probability. Pearson correlation was carried out between soil physical properties and yield.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Soil physicochemical properties of the study area

The result of the physicochemical properties of 0 – 10cm soil surface layer of the experimental area before the commencement of the study area are shown in Table 1. The pH was 7.7 which is alkaline, soil organic matter is 3.20 while the total nitrogen was 147.00. The soil particle analysis showed that the clay, silt and sand content are 36.40%, 17.90% and 45.70%, giving it sandy loam texture.

Table 1: Physicochemical properties of the study area

Parameter	Value
Ph	7.7
Electrical Conductivity (μs/cm)	95.00
Cation Exchange Capacity (meq/100g)	47.61
Organic Matter (%)	3.20
Base Saturation (%)	62.67
Hydraulic Conductivity (cmhr^{-1})	0.39
Available N (Kg/ha)	147.00
Available P (Kg/ha)	96.00
Available K (Kg/ha)	212.00
Sand (%)	45.70
Silt (%)	17.90
Clay (%)	36.40
Textural class	Sandy-clay loam

4.2 Effect of drip irrigation frequency and mulching material on okra plant height

The observation of the effect of irrigation frequency and mulching material on okra plant height is shown in Table 2 and figure 2. The mean plant heights as influenced by different irrigation regimes are shown in table 3, and figure 3. The influence of irrigation regime recorded insignificant means for the plant height across the weeks under observation as the difference between the means were less than the LSD ($P<0.05$). On the contrary, the mulching methods recorded significant mean difference at weeks after planting, 6 weeks after planting and 8 weeks after planting, but insignificant mean difference at 2 weeks after planting. Among the three mulching materials, M1 had the most influence on the height -of the plant, followed by plastic mulch and natural mulch respectively.

Table 2: Effect of drip irrigation frequency and mulching material on okra plant height.

-Treatment	2	4	6	8
	----------Weeks after planting----------			
F1	8.7	32.1	38.1	45.4
F2	9.2	30.4	39.0	46.6
F3	8.4	29.6	37.1	46.6
LSD(p<0.05)	0.931^{ns}	0.511^{ns}	0.416^{ns}	0.202^{ns}
M1	9.2	33.4	41.3	50.0
M2	8.2	30.3	37.7	45.3
M3	8.8	28.3	35.1	43.3
LSD(p<0.05)	1.48^{ns}	2.01^{s}	4.44^{s}	4.88^{s}
SEM	0.40	1.79	1.48	1.54

F1 = Once, F2 = Twice F3= Thrice, M1 = No mulch, M2 = Plastic mulch, M3 = Natural mulch, F = effect of irrigation frequency; M = effect of mulching; ns = no significant difference between mean values at 5% level of probability by (LSD) test, s = significant difference between mean values at 5% level of probability by (LSD) test, SEM: standard error of mean

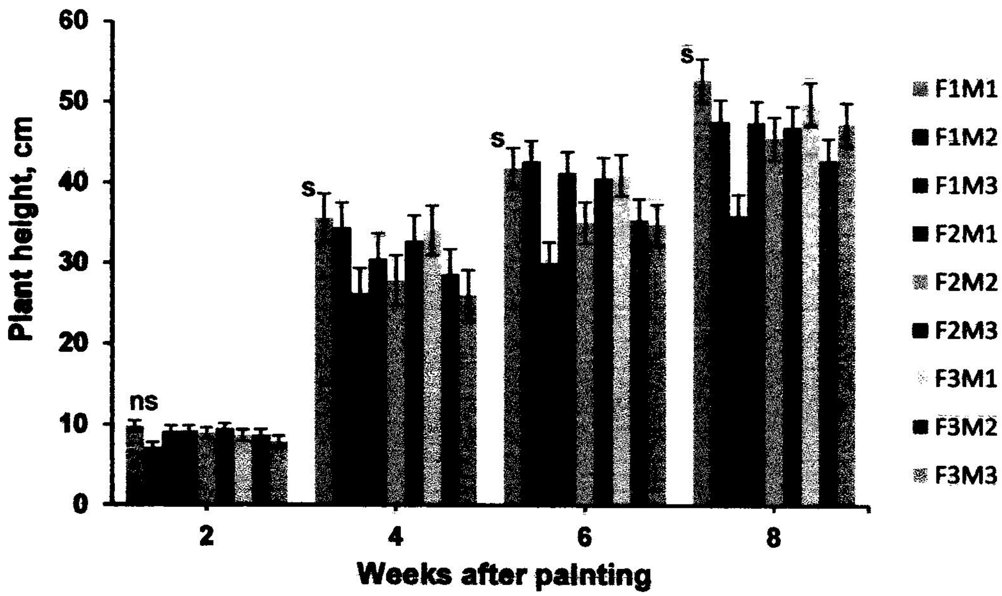

Fig 2. Interactions of drip irrigation frequency and mulching materials on okra plant height.

F1M1- Daily and No mulch, F1M2- Daily and plastic mulch, F1M3- Daily and Natural mulch. F2M1- Twice and No mulch, F2M2- Twice and Plastic mulch, F2M3- Twice and Natural mulch, F3M1- Thrice and No mulch, F3M2- Thrice and Plastic mulch, F3M3- Thrice and Natural mulch; ns: no significant difference between mean values at 5% level of probability by least significant difference (LSD) test; s: significant difference between mean values at 5% level of probability by least significant difference (LSD) test.

4.3 Effect of drip irrigation frequency and mulching material on number of leaves of okra

The observation of the effect of irrigation frequency and mulching material on number of leaves of okra is shown in table 3 and figure 3. The influence of irrigation regime recorded insignificant means for the number of leaves across the weeks under observation as the difference between the means were less than the LSD ($P<0.05$). A similar trend was recorded in the effect of mulching for 2 weeks, 4 weeks and 6 weeks after planting. On the contrary, significant differences were recorded for the 8th week after planting. No mulch had more influence on the number of leaves. This was followed by plastic mulch and natural mulch respectively.

Table 3: Effect of drip irrigation frequency and mulching material on number of leaves of okra.

Treatment	2	4	6	8
	----------Weeks after planting----------			
F1	4.32	5.93	9.33	11.55
F2	4.23	5.84	8.10	11.37
F3	4.29	5.38	8.21	12.49
LSD(p<0.05)	0.16^{ns}	0.83^{ns}	1.27^{ns}	0.57^{ns}
M1	4.24	6.32	9.47	13.87
M2	4.31	5.33	7.64	11.35
M3	4.28	5.49	8.53	10.19
LSD(p<0.05)	0.10^{ns}	2.72^{ns}	2.27^{ns}	5.57^{s}
SEM	0.12	0.32	0.61	0.80

F1 = Once, F2 = Twice F3= Thrice, M1 = No mulch, M2 = Plastic mulch, M3 = Natural mulch, F = effect of irrigation frequency; M = effect of mulching; ns = no significant difference between mean values at 5% level of probability by (LSD) test, s = significant difference between mean values at 5% level of probability by (LSD) test, SEM: standard error of mean; ns: no significant difference between mean values at 5% level of probability by least significant difference (LSD) test, s: significant difference between mean values at 5% level of probability by least significant difference (LSD) test; SEM: standard error of mean

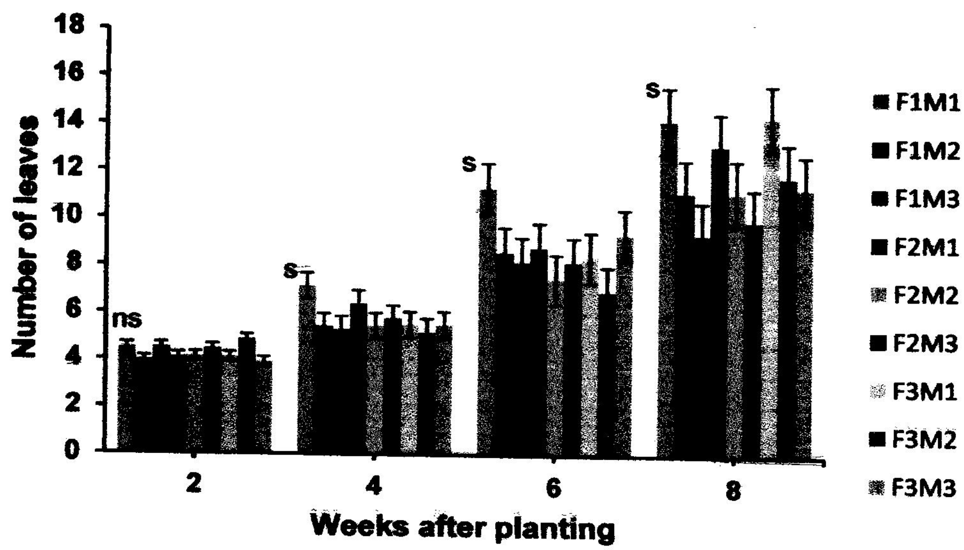

Fig 3. Interactive effect of drip irrigation frequency and mulching materials on okro plant height.

F1M1- Daily and No mulch, F1M2- Daily and plastic mulch, F1M3- Daily and Natural mulch, F2M1- Twice and No mulch, F2M2- Twice and Plastic mulch, F2M3- Twice and Natural mulch, F3M1- Thrice and No mulch, F3M2- Thrice and Plastic mulch, F3M3- Thrice and Natural mulch; s: significant difference between mean values at 5% level of probability by least significant difference (LSD) test.; ns: no significant difference between mean values at 5% level of probability by least significant difference (LSD) test.

4.4 Effect of drip irrigation frequency and mulching materials on yield and yield attributes of okra.

The effects of irrigation schedule gave insignificant mean differences among the yield and attributes as shown in table 4. The evaluation which includes fruit length, fruit diameter, number of branches, number of fruits, fruit weight (kg/m^2). On the contrary, significant differences were recorded for the effect of mulching methods on the yield and yield components of okra as there were significant mean differences for fruit length, number of branches, number of fruits and fruit weight per hectare. Fruit diameter was not significantly different. Among all the fruit yield and yield components, daily irrigation and no mulch gave the highest values. This was followed by twice irrigation + no mulch and thrice irrigation + no mulch. The least values were obtained in thrice irrigation + natural mulch and daily irrigation + natural mulch.

Table 4. Effect of drip irrigation frequency and mulching materials on yield and yield attributes of okra.

Freq.	Mulching	FrtLngth, cm	FrtDia, cm	NoBranch	NoFrt	FrtWt, kg/m^2
	M1	5.91	2.55	2.05	4.91	26.05
F1	M2	6.00	2.64	1.32	5.24	22.16
	M3	5.66	2.67	1.10	2.79	18.85
	M1	5.80	2.63	1.84	4.72	25.01
F2	M2	5.58	2.53	1.68	4.79	23.44
	M3	4.89	2.65	1.13	2.98	19.51
	M1	6.02	2.50	0.90	4.86	24.49
F3	M2	5.56	2.36	1.99	4.98	23.53
	M3	4.61	2.50	1.42	2.96	18.43
	SEM	0.24	0.11	0.15	0.22	1.86
	F	3.40^{s}	2.10^{ns}	0.40^{ns}	0.35^{ns}	0.06^{ns}
	M	10.29^{s}	0.57^{ns}	7.79^{s}	81.81^{s}	8.80^{s}
	F x M	0.25^{ns}	0.88^{ns}	0.00^{ns}	0.70^{ns}	0.94^{ns}

F1 = Once, F2 = Twice F3= Thrice, M1 = No mulch, M2 = Plastic mulch, M3 = Natural mulch, F = effect of irrigation frequency; M = effect of mulching; F x M = interactive effect of irrigation frequency and mulching material, ns = no significant difference between mean values at 5% level of probability by (LSD) test, s = significant difference between mean values at 5% level of probability by (LSD) test, SEM: standard error of mean

4.5 Correlation among growth parameters, yield and yield components

Pearson correlation coefficient among growth parameters, yield and yield components is shown in table 5. Fruit weight recorded positively significant association ($P<0.01$) with number of fruits (0.583^{**}). This implies that the number of fruits per plant influences the fruit yield; hence, the more the number of fruits, the more yield that will be realized. On the contrary, fruit weight recorded significantly negative correlation coefficient with fruit diameter (-0.341*). Plant height recorded positively significant correlation coefficient ($P<0.01$) with number of leaves (0.654*). Fruit length recorded positively significant correlation coefficient with number of fruits (0.497^{**}) and fruit diameter at $P<0.01$ and $P<0.05$ respectively. Number of branches recorded positively significant correlation ($P<0.05$) coefficient with number of fruits.

Table 5. Correlation among growth parameters, yield and yield components

Parameter	Frtwt	PH	NOL	FrtLn	FrtDia	NoBran	NoFrt
Frtwt		0.178	0.224	0.212	-0.341^{*}	0.244	0.583^{**}
PH			0.654^{**}	0.164	-0.026	0.062	0.300
NOL				0.263	-0.045	0.236	0.122
FrtLn					0.336^{*}	0.076	0.497^{**}
FrtDia						-0.015	-0.171
NoBran							0.394^{*}
NoFrt							

* = significant at 0.05 (2-tail), ** = significant at 0.01 (2-tail), Frtwt = fruit weight; PH = plant height; NOL = number of leaves; FrtLn = fruit length; FrtDia = fruit diameter; NBran = number of branches; NoFrt = number of fruits

4.6 Effect of drip irrigation on the selected soil physical properties

The effect of drip irrigation system on soil physical properties is displayed in table 6. The F1 shows not to be significantly different from F2 but differ from F3 in the bulk density value. Also, the showed not to be significantly different from F3 in their mean value. this result shows that the frequency of irrigation affects soil bulk density, that is, has water is consistently apply on soil there would be decrease in bulk density of such soil.

Moreover, mean value of the total porosity shows not to be significantly different from one another. This implies that, the consistent watering of land does not affect the porosity of such land.

The gravimetric water content result shows that F1 and F2 are not significantly different from one other but differ from F3, meaning when a land is consistently irrigated especially thrice a day, the GWC of such land tends to increase.

Lastly on this note, the result of the saturated hydraulic conductivity shows no significant difference from one another. This means that the experimented land won't be saturated after it might have been watered three times a day.

Table 6 Effect of drip irrigation on soil physical properties

Irrigation	Mean BD	Total porosity	Gwc	Ksat
F1	1.82833a	0.38583a	1.3483a	36.004a
F2	1.6417ab	0.40750a	1.1825a	39.606a
F3	1.59333b	0.40000a	0.7108b	39.359a

4.7 Effect of mulching on some selected soil physical properties

Table 7 shows the result of different mulching methods on soil physical properties. The bulk density value gotten for M1 is significantly different from that of M2 but it is not different from M3. Also, M2 was not different from M3. This implies that when a land is not mulched and when natural mulch is used on the experimented land there happens to be no significant decrease in the bulk density of such soil but when plastic mulch is used, there is a drastic decrease in the bulk density of the land.

Considering the total porosity, the result in table 8 shows that there are no significant differences in all the three mulching method used as regard the total porosity. This means that the porosity rate does not differ from one another on the land even has the three mulching methods were adopted.

Moreover, the M1 and M2 showed no significant different from each other but differ from M3, this tells us that no mulch and plastic mulch does not really help to retain moisture on the land but rather natural mulching appears to be the best on the land to retain water.

For the saturated hydraulic conductivity, the result shows that M1, M2 and M3 are significantly different from one another respectively. This implies that the three mulching method have a great influence on the saturated hydraulic conductivity of the land.

Table 7: Effect of mulching on soil physical properties Mulching

Irrigation	BD	TOTAL POROSITY	GWC	Ksat
M1	1.80417a	0.39500a	1.7925a	42.233a
M2	1.55917b	0.41250a	1.6358a	40.271b
M3	1.62250ab	0.38583a	1.0133b	38.465c

4.8 Effect of irrigation and mulching on some physical properties

The result in table 8 below shows that the combination of F2 and M2 gave the lowest bulk density value of 1.53±0.14 while F1M1 and F3M1 have the highest value for the soil bulk density. This implies that when the experimented land is watered twice a week and plastic mulch is adopted there would be decrease in bulk density but no mulch appears to increase bulk density.

For the total porosity the F1M1 has the lowest value 0.39±0.03 while F2M2 has the highest value of 0.43±0.08. This means one time drip irrigation and no mulch lowers the porosity of the land but when the land is irrigated twice with plastic mulch the porosity of the land increases.

The result of gravimetric water shows that F3M1 and F1M2 appears to increase water retention while F2 and M1 has the lowest water retention.

The plastic mulch and twice watering of the land increases the saturated hydraulic conductivity.

Table 8: Interaction table of irrigation and mulching methods affecting soil physical properties.

Level of Irrigation	Mulching	BD	Level of TOTAL POROSITY	GWC	Ksat
F1	M1	1.62±0.05	0.39±0.03	0.82±0.09	37.36±0.65
F1	M2	1.56±0.10	0.41±0.05	1.08±0.18	35.38±0.49
F1	M3	1.71±0.12	0.36±0.07	0.95±0.28	35.28±0.56
F2	M1	1.58±0.12	0.41±0.07	0.31±0.13	38.41±0.71
F2	M2	1.53±0.14	0.43±0.08	0.75±0.20	40.34±0.62
F2	M3	1.59±0.08	0.39±0.05	0.99±0.18	40.07±0.53
F3	M1	1.62±0.11	0.39±0.07	1.25±0.25	38.93±0.87
F3	M2	1.59±0.06	0.40±0.04	0.68±0.15	39.10±0.89
F3	M3	1.57±0.10	0.41±0.06	1.10±0.17	40.05±0.76

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Drip irrigation is an essential method of irrigation system to be adopted. From the research work it was observed that drip irrigation and mulching affects soil physical properties of the soil and affect the yield of okra.

Also, the effects of irrigation schedule gave insignificant mean differences among the yield and attributes evaluated which includes fruit length, fruit diameter, number of branches, number of fruits, fruit weight (kg/m2). On the contrary, significant differences were recorded for the effect of mulching methods on the yield and yield components of okra as there were significant mean differences for fruit length, number of branches, number of fruits and fruit weight per hectare. Fruit diameter recorded insignificant mean differences. Among all the fruit yield and yield components, daily irrigation and no mulch gave the highest values. This was followed by twice irrigation + no mulch and thrice irrigation + no mulch. The least values were obtained in thrice irrigation + natural mulch and daily irrigation + natural mulch.

The Pearson correlation coefficient gave some important information on the growth parameters, yield and yield components are shown in table 4. Fruit weight recorded positively significant association ($P<0.01$) with number of fruits (0.583**). On the contrary, fruit weight recorded significantly negative correlation coefficient with fruit diameter (-0.341*). pH recorded positively significant correlation coefficient ($P<0.01$) with number of leaves (0.654*)

5.2 Recommendation

This research is recommended for further trials by other researchers to generate more reliable information.

REFERENCES

Aladele, S.E., OJ. Ariyo and R. de Lapena, 2008. Genetic relationship among West Africa okra (Abelmoschus caillei) and Asian genotypes (Abelmoschus esculentus) using RAPD, Afr. J. Biotechnological., 7:1426-1431.

Aruleba, J. O. (2011). Elements of soil science. Arubeba A. Lucy Enterprises, 1st Edition, pp. 157.

Assaouline, S. (2002). The effects of micro drip and conventional drip irrigation on water distribution and uptake. Soil Science Soc. Am. J. , 66 (5): 1630 – 1636.

Beat S. M. (2011). Drip irrigation techniques. Centre pivot irrigation in the south of British Colombia, Canada. (seecon international gbbh).

Cameira, M. R., Fernando, R. M. and Pereira, L. S. (2003). Soil macropore dynamics affected by tillage and irrigation for a silt loam alluvial soil in southern Portugal. Soil Till. Res. 70; 131 – 140.

Cockroft, B. and Olsen, K. A. (2000). Degradation of soil structure due to coalescence of aggregates in no till, no traffic bed in irrigated crops. Australian Journal of Soil Research. 38: 67 – 70.

Currie, D. R., Grant, C. D., Murray, R. S. and McCarthy, M. G. (2006). Drip irrigation can degrade soil structure in vineyard: evidence and implications. 5th International Symposium on irrigation of Horticultural Crops, Mildura, August 2006. Proceeding.

Dalvi, V. B., Tiwari, K. N., Pawade, M. N. and Phirke, P. S. (1999). Response surface analysis of tomato production under micro irrigation. Agric. Water Management, 41:11-19

Dexter, A. R. (1998). Advances in characterization of soil structure. Soil and Tillage Research, 11:199 – 238.

Emuh, **IF.N.** , A.E. Ofuoku and E. Oyefia (2006). Effect of Intercropping Okra (Hibiscus esclentus) with Pumpkin (Curcubita maxima Dutch ex Lam) on Some Growth Parameters and Economic Yield of Maize (Zea mays) and Maximization of Land Use in a Fadama Soil Research Journal of Biological Sciences 1 (1-4): 50-54.

FAO (1986). Early Agrometeoroligical crop yield forecasting. FAO Plant production and protection paper no. 73, by Mr. Frere and G. F, popov. FAO, Rome, Italy.

FAO (1988). Irrigation practice and water management. L. D. Doneen and D. W. Westcot. Irrigation Paper 1, Rev. I. FAO, Rome. 71p.

Fasina, A. S., Awe, G. O. and Aruleba, J. O. (2008). Irrigation suitability evaluation and crop yield. An example with Amaranthus curentus in south-western Nigeria. African Journal of plant science. 2(7): 061-066.

Hamblin, A. P. (1985). The influence of soil structure on water movement, crop root growth, and water uptake. Advances in Agronomy 38:95 – 158

Hamblin, A. P. (1985). The influence of soil structure on water-movement, crop root-growth, and water-uptake. Advances in Agronomy. 38:95-158

Irrigation on okra (Abelmoschus esculentus.). International Journal of Plant Production 1(1).

Letey, J. (1985). Relationship between soil physical properties and crop production. Advances in Soil Science, 1:277 – 294.

Segal, E., Ben-Gal, A. and Shani, U. (2000). Water availability and yield response to high-frequency micro-irrigation in sunflowers, Proceedings of the Sixth International Micro-irrigation Congress on 'Micro-irrigation Technology for Developing Agriculture', Conference Papers, 22 – 27 October, South Africa.

Singh D.K, and T.B.S. Rajput (2007) Response of lateral placement depths of subsurface drip

Wang, H., Zhang, L., Dawes, W. R. and Liu, C. (2001). Improving water use efficiency of irrigated crops in the North China Plain-measurement and modeling. Agric. Water management, 47: 151-167

APPENDIX

Appendix 1: Anova table showing the effect of irrigation and mulching on physical properties

Sov	DF	Bd	Total porosity	Gwc	ksat
Rep	3	0.008ns	0.001ns	0.030ns	51.812ns
Irrigation	2	0.012ns	0.001ns	0.365ns	48.578ns
Mulching	2	0.013ns	0.002ns	0.164ns	0.186ns
Irrigation* Mulching	4	0.008ns	0.001ns	0.365ns	5.557ns
Mean		1.595ns	0.398ns	0.881ns	38.323ns
Cv(%)		11.752ns	17.791ns	76.738ns	21.496ns