EFFECT OF IRRIGATION INTERVAL AND PLANT DENSITY ON THE GROWTH AND YIELD OF TWO TOMATO (Lyeopersicon esculcntum Mill) CULTIVARS AT SAMARU, NIGERIA

BY

RILWANU DAYI UMAR

A thesis submitted to the Postgraduate School, Ahmadu Bello University, Zaria,
in partial fulfilment of the requirement for the degree of Master of Science in Agronomy.

DEPARTMENT OF AGRONOMY, FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.

FEB. 1999

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree.

RILWANU DAYI UMAR
(Student)

Date: 25/3/1999

The above declaration is confirmed

27/4/99
DR. E. B. AMANS
(Major Supervisor)

Date:-------------------------------

CERTIFICATION

This thesis entitled "Effect of Irrigation Interval and Plant Density on the Growth and Yield of two Tomato (Lycopersicon esculentum Mill) Cultivars at Samaru Nigeria" by Rilwanu Dayi Umar meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

27/4/99
Dr. E. B. Amans
Chairman, Supervisory Committee
and Head of Agronomy Department.

14/05/99
Prof. V. B. Ogunlela
Member, Supervisory Committee

Dean, Postgraduate School

Date: 28/12/00

AHMADU BELLO UNIVERSITY, ZARIA.

ABSTRACT

Field trials were conducted at the Institute for Agricultural Research (I.A.R) farm Samaru, Zaria, during the 1994/95 and 1995/96 dry seasons to determine the response of two tomato (Lycopersicon esculentum Mill) cultivars to varying irrigation interval and plant density. The treatments consisted of two tomato cultivars namely TI106 and TI 539, three irrigation intervals (5, 10 and 15 days) and three plant densities (27750, 55500 and 83250 plants/ha). These were arranged in a split-plot design in which the combinations of irrigation interval and plant density were allocated to the main plots while the varieties were assigned to sub plots and these were replicated three times. The result indicated that variety TI 106 was significantly superior to TI 539 in terms of all growth parameters, such as total fruit yield per hectare, fruit yield per plant, and proportion of unmarketable fruits. However, TI 539 has significantly larger fruits size than TI 106. Extension of irrigation interval from 5 to 15 days reduced growth and yield parameters measured on both trials. The proportion of unmarketable fruits was however significantly reduced by drier condition as the irrigation interval was extended from 5 to 15 days. The plant height, leaf area index and total yield per hectare responded positively to increassing plant density from 27750 to 83250 plants/ha although the differences between 5550 and 83250 plants/ha were not significant. But unlike the positive response of the plant height, leaf area index and total fruit yield/ha to increasing plant density and other growth and yield parameters responded negatively to increasing plant density beyond 27750 plants/ha. In the 1995/96 dry season trial, significant and positive correlation (P-0.01) was obseived between tomato total fruit yield/ha and growth and yield parameters tested, except with the exception of leaf area index.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to Dr. E. B. Amans, the Chairman of my Supervisory Committee and Head of Agronomy Department for his encouragement, guidance, useful suggestions and constructive criticisms throughout the course of the study. The same sincere appreciation is extended to Prof. V. B. Ogunlela and Dr. J. A. Adigun, now of the University of Agriculture Abeokuta both of whom served as members of the supervisory committee, for their objective criticisms and suggestions rendered throughout the period of the work.

Also, I recognise the commendable assistance I received from members of staff of the Agronomy Department. In particular, I appreciate the efforts of Dr. A.M. Falaki, Mallam Bashir A. Babaji, Dr. Balarabe Tanimu, Dr. Lamido Aliyu, Messrs Rufai Ibrahim, Sani Miko, Ahmed Ibrahim, I.U. Abubakar, Mrs. C.C. Shinggu, Mr. James Naman and Mr. Paul O. Nnorom. Gratitude is also extended to my parents, wife Umma and relatives for their immense moral support and understanding. Among friends, I consider it necessary to acknowledge and appreciate the efforts of Shu'aibu Adamu and Dauda I. Daudawa.

My special appreciation goes to the Management of Hassan Usman Katsina, Polytechnic Katsina for sponsoring the entire study. The effort of Mal. Sani A. Dirisu of Agronomy Department, Ahmadu Bello University, Zaria, who typed the thesis, is highly acknowledged.

Finally, praise be to Allah (S.W.A.) Who sustained me throughout the period.

The study showed that the best marketable yield of tomato at Samaru was recorded with a 5- days irrigation interval under a plant density of 83,250 plants/ha. Variety TI106 proved to be a better yielder than TI 539.

TABLE OF CONTENTS

CHAPTER TWO

CHAPTER THREE

LIST OF TABLES

LIST OF ABBREVIATIONS

%	=	Percentage
°C	=	Degree Celsius
cm	=	Centimeter
et al	=	and others
g	=	gramme
k	=	kilogramme
ha	=	Hectare
hrs	=	Hours
m	=	metre
m^2	=	meter square
mm	=	milimetre
$P_2 0_5$	=	Phosphorus pentaoxide
t	=	Tonnes
WAT	=	Weeks after transplanting
DMRT	=	Duncan's Multiple Range Test

CHAPTER ONE

1.0 INTRODUCTION

1.1 Environmental Requirement of Tomato.

The cultivated tomato (*Lycopersicon esculentum*, Mill) is a vegetable crop belonging to the family Solanaceae. It is considered the most important fruit vegetable on world basis, The plant requires warm day temperatures (21^0 - 28°C) and moderately cool night temperatures (15^0 - 20°C) for optimum growth and development. Fruit setting is reduced by temperatures which are either too low or too high and it is inhibited by temperatures below 13°C. Both high and low temperatures can also adversely affect fruit quality, particularly colour development. (Grubben, 1977). Excessive rainfall or water supply causes adverse effects on the tomato crop, particularly, if it is not staked, due to the spread of fungal disease. The plant however requires adequate water supply during its growth period, about 8 - 10 mm per day during the period of fruit development. Well-drained, fertile soils with a good moisture retaining capacity and relatively high level of organic materials, are best for tomato production. However many cultivars tolerate a wide range of soil conditions soils with pH levels of 5.0 - 6.5, (Rice and Tindall, 1986).

1.2 Economic Importance

Tomato has made significant contribution to human nutrition as a rich source of many essential nutrients and vitamins such as vitamins A,B and C. The fruit may be eaten fresh as salads or processed into a paste, which are cooked to make stews and soups. However, as an agro-industrial raw material, large quantities of tomato fruits can be processed into various canned or bottled products such as puree, ketchup and juice for human food uses. The seeds of tomato contain about 24% oil, which can be extracted and used as salad oil, and in the manufacture of margarine and soap. After the oil extraction the residual cake is used as livestock feed and manure (Purseglove, 1968).

Documented evidence tends to indicate that the global tomato production has been on a steady increase. Food and Agricultural Organisation (FAO) statistics puts the annual world tomato output at over 75 million metric tonnes from a total land area of about 3 million hectares (Anon, 1993a). In Nigeria, the total output for the crop has increased from 403,000 tonnes in 1981 to 670,000 tonnes in 1992 from a corresponding production areas of 38,000 ha and 55,000 ha, respectively (Anon. 1993a). Much of the production is confined to the less humid northern parts of the country i.e (the Guinea and Sudan/Sahel savanna zones. The most favourable season for tomato production, even in the savannas, is the dry season (October - April) which is a period when the weather is cool and thus, pest and disease problems are minimal. Although its production has continued to increase steadily, the average yields per hectare are still low, about 15 - 20 tonnes. The potential yield in the Nigerian savanna under dry season (irrigated) condition was reported to be at about 50 t/ha or more (Quinn, 1980; Erinle, 1989).

1.3 Justification for the Research.

The wide gap between the farmers' present yield average and the potential yield of tomato in Nigeria is indicative of several constraining factors, that are limiting tomato production. Some of these limiting factors are environmental, while others are agronomic (cultural) or management in nature. Relative high temperatures, for most of the year, excessive humidity as well as pest and disease problems during the rainy season, and inadequate water for irrigation during the dry season are the important environmental constraints. Low soil fertility is also a major environmental constraint in most Nigerian soils,

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Irrigation Requirement of Tomato Crop.

Adequate and timely water supply to crops under arid and semi-arid conditions are major pre-requisites to increased yields. A number of studies have been carried out in some parts of the world to support this assertion, even though many local environmental variables do influence final crop responses to irrigation. The frequency and amount of applied water is a function of weather conditions, crop, variety, stage of growth, rooting characteristic, soil water retention capacity, irrigation system and management factors (Phene et al. 1989). Due to its tender and succulent nature, the tomato plant has a high water requirement and it yields better when grown under adequate irrigation.

2.1.1 Effect of irrigation interval on plant growth.

Tomato growth cycle can be divided into three distinct morphological stage, namely vegetative, flowering and fruiting stages. Salter (1958), observed that high moisture supply encouraged excessive vegetative growth, but there was a drastic reduction in vegetative growth under conditions where the soil was allowed to dry between irrigations to near wilting point. Martin (1966) reported that excessive irrigation delayed crop maturity. Alibury and May (1970) indicated that long irrigation interval stressed plants. In another trial, Hernado and Orihuel (1979) found that plant growth and development were significantly affected by irrigation regime with reductions in growth as the irrigation interval was increased from 5 to 10, 15 and 20 days. Thus, the aim is neither to provide excessive water through frequent irrigation nor stress the plants by too long irrigation interval.

Babalola and Fawusi (1980) investigated the effect of three moisture levels under greenhouse and field conditions on the growth and water relations of the tomato cultivars, "Fireball" and "Ife I". They noted that "Ife I" was more drought susceptible than "Fireball" and the drought susceptibility of this cultivar increased with increasing level of soil moisture stress. The drought tolerance of "Fireball" was attributed to its smaller leaf area, better rooting depth, as well as a higher water potential. The same workers also reported that the higher leaf stomatal resistance of "Fireball" suggested an in built mechanism for regulating water vapour flow in time of stress.

Amico et al. (1985) reported that tomato growth and the thickness of the plant stem were adversely affected by water stress. They noted a decrease in growth and thickness of the plant stem with water deficit at critical stages of development. But Snyder and Bauelre (1985) reported that watering frequencies of 1, 4 or 8 times per day had no significant effect on leaf area and total number of flowers per plant. However, in a trial conducted by Nwadukwe (1986) at Kadawa, in the Sudan savanna of Nigeria, on tomato cultivar "Ife I", three irrigation frequencies at one, two and three- week intervals were tested. The result of this work showed that the one week irrigation interval provided an optimum condition for root growth under deep water-table conditions. But for shallow water-table, a two- week irrigation was found to be optimum. Moses (1995) found that irrigation frequency significantly affected all the growth components like plant height, number of branches per plant and number of leaves per plant.

2.1.2 Effect of irrigation interval on fruit yield.

As was observed with plant growth responses, the fruit yield of tomato was also affected by irrigation frequencies. Several or all the yield contributing factors or components may be affected by varying degrees of irrigation. In a glasshouse experiment , Salter (1958) reported that longer irrigation intervals depressed yield and increased the percentage of sun-burned fruits. In a similar development, Martin (1966) indicated that high irrigation rate reduced the yield and solids content of tomato fruits. However, Sakiyama (1968) revealed that all the titratable, total and combined acidities expressed on a fresh weight basis were lowest for fruits from plants irrigated daily and highest for fruit from plants receiving the least frequent irrigation. But it was also found that the more frequent the irrigation the greater the fruit weight.

In an experiment carried out on clay soils, an irrigation interval of 7 or 8 days interval was recommended for best yield of tomato (Deidda and Marras, 1970). While Caliandro reported that the number and size of fruits as well as yield of saleable fruits, were significantly increased by increasing frequency of irrigation. The proportion of discarded fruit due to blossom-end rot was also reduced. In a similar work, Doss (1973) noted that irrigation increased total marketable tomato yields only at moderate levels. He also reported that average fruit yields from a 3-year experiment were about 58300, 70000 and 68,900kg/ha for the zero, intermediate and high irrigation treatments, respectively. Zerbi (1974) also reported that yields were maximized at the intermediate irrigation frequencies of 2 to 12 days rather than at daily or longer intervals. However, the dry matter content was positively correlated with number of days between the irrigations. Amable and Sinnadurai (1977) in a trial with box grown tomatoes, found that irrigation applied every 3 days led to a decrease in soluble solid and titratable acidity compared with a longer irrigation interval of 5 days.

Anonymous (1987), in a trial with tomato CV ROMA-VF, provided 50mm of irrigation water per plot at a interval of 5, 7 or 9 days. It was reported that the highest yield was obtained with the 7-day irrigation interval. Further work by the same workers revealed the best yield was again recorded with the 7-day irrigation interval, although this was not significantly different from the fruit yield obtained with the 14-day interval.

Kwapata (1991) reported that yields of tomato cultivars were improved with increasing irrigation frequency from 2 to 4 times per week when 1.5 liters of water was applied per plant at each irrigation time. The number of fruits per plant increased with increasing irrigation frequency. But on the average, the irrigation frequency of 3 times per week was best for optimum tomato production. Thus, tomato responded favourably to low frequency application of water. Fapohunda (1992) found that tomato yield had high correlations with both frequency and amount of irrigation.

2.2 Plant Density Effect

The population of plants within a unit area, which is also refered to as plant density, has a direct bearing on the degree of interplant competition for available nutrient and water resources. Increasing plant density could increase yield through having more plants per unit area, but at the same time the level of interplant competition increases, often with significant adverse effects on the crop performance. The following review, highlights the significance of varying plant density on tomatoes.

2.2.1 The effect of plant density on tomato growth.

Hisatomi (1972) reported that leaf area and stem thickness were greater at lower than at higher planting densities. Rodriques and Lambeth (1973) found that wide spacing increased the number of flowers per plant. Similarly, Petrukhina and Belaya (1986) found that increasing tomato plant density both per stand and per hectare led to a reduction in the numbers of main shoots, leave, and reproductive organs. Papadopoulos (1988) observed that closer spacing decreased the leaf area and thus net photosynthesis.

2.2.2 The effect of plant density on yield.

Bryan (1970) reported that fruit number per plant was reduced with increasing plant density. While, Gapinski (1971) observed that increasing plant density from 480,000 to 650,000 plants/ha resulted in higher yield and early crop maturity. Hisatomi (1972) found that fruit number per unit area and total fruit yield in tomatoes were greater at high than at low planting density. In a similar development, Zaharan and Tamm (1973) observed that the highest yield of marketable fruits (104.9t/ha) was obtained at a plant density of 617,550 plants/ha. However, Abdel-Al (1973) reported that plant population had no significant effects on percentage soluble solids, pH and titratable acidity, but higher plant population tended to give slight improvement in fruit colour.

Adelana (1976) studied the effect of varying plant densities (10,000, 20,000, 30,000 plants/ha), on tomato yield in Western Nigeria and found that although the maximum fruit yield was obtained from the level of highest plant density, the yield increase which occurred above 30,000 plants/ha was not significant. Similarly, Gupta and Shukla (1977) reported that although yield per unit area was highest at the closest plant spacing (45 x 45cm), the mean yields per plant were highest at wide spacings (75 x75cm and 75 x 60cm). Postglione and Lanza (1978) also reported that as planting density increased the production of ripe fruits/ha increased but the mean fruit weight and number of fruits per plant were reduced. Hamer and Olabi (1985) found that increase in plant density reduced the number of fruits and yield per plant.

Nasser (1986) reported, in 2-year study using variety CV 97.3, seedling planted at plant densities varying between 12000 - 36000 plants/ha, observed that fruit yields were best (30.2 - 32.3t/ha) at the highest planting density. Mohammed and Ali (1986) indicated that reducing inter-plant spacing from 60 to 40cm resulted in a yield increase of 24% in the first season and 38% in the second. A further reduction in spacing to 20cm resulted in a yield increase of 43% in the first season and 75% in the second. The closest spacing of 20cm also reduced the number of sun-scalded fruits compared with the wider spacing of 60cm. Similarly, Hassan (1978) reported that closer spacing decreased cracking and sunscald incidence but had no effect on any other fruit quality.

In a study conducted at Kadawa Amans (1988) observed that yield per hectare in tomato responded positively to increasing plant density, with much of the variance occurring between 22200 to 44400 plants/ha. As plant density was increased so did the negative effect of inter-plant competition and individual plant productivity gradually declined at densities above 44400 plants/ha. However yield per hectare was maximum at densities between 59200 and 74,000 plants/ha. Seno and Kimoto, (1989) experimented with three tomato cultivars, namely, Roma VFN,CAL-J and UC-82 planted at densities of 47056, 67233 and 117640 plants/ha. The results of this work showed that the yield of marketable fruits was highest (78.7t/ha) at the lowest density and declined to 70t/ha at the highest plant density. He also reported that a similar trend was observed with regards to mean fruit weight and productivity per plant. Similarly Smith, et al (1992) reported that increasing plant density of cultivar US-68 (by changing the spacing from 23cm in single rows to 30cm in double rows) increased the total fruit yield substantially, lowered yield per plant and decreased fruit weight slightly.

2.3 Factor Interactions

Crop response to any one environmental factor is often influenced to varying degrees by one or more other factors. Studying the degree or significance of how one factor influences the effect of another factor is a valuable component of factorial experiments.

Moore et al. (1958) reported that increasing plant density by closer interplant spacing was an important means of increasing tomato yields. However, these same workers observed that such a benefit derivable from a higher plant density is further enhanced when adequate irrigation is provided. In the work reported by Casarini (1966), two tomato varieties (San Marzano and C-1402) were subjected to irrigation frequencies varying from once every week to a single application in four weeks. The result showed that variety "San-Marzano" was more responsive to irrigation frequency, than var C-1402, while the yield of "San-Marzano" declined significantly at irrigation intervals longer than once per week, that of "C-1402" was less affected until the irrigation interval reached once in four weeks.

The interaction between crop variety and irrigation interval or plant density was reported as being significant in a two-year experiment in the Sudan (Abdel-Al, 1973). In that experiment, differential responses to irrigation interval (weekly versus fortnightly) were observed among the five varieties tested. Experiments in the Nigerian Savanna indicate that tomato crop response to planting density could vary significantly with the type of cultivar. After years of variety evaluation, Quinn (1980) concluded that some determinate tomato cultivars may require a closer interplant spacing than others. In another experiment with three cultivars planted at varying densities varying between 22200 and 88890 plants/ha, Amans (1988) observed some significant factor interactions, although the results were not consistent over the years. In an experiment conducted by the same worker at Kadawa (Nigeria) under conditions of a high soil water-table, it was found that a higher plant density helped to ameliorated the negative effect of excessive soil moisture (Amans, 1992).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

Field trials were conducted under irrigation during the 1994/95 and 1995/96 dry seasons at the research farm of the Institute for Agricultural Research (IAR), Samaru (11° 12' N, 07°38' E, 686m above sea level) in the northern Guinea savanna ecological zone of Nigeria. The soils of the sites in both seasons were loamy soils. Details of the physico-chemical analysis of the soils are presented in Appendix I while meteorological data are presented in Appendices II and III

3.2 Treatments and Experimental Design.

Treatments tested consisted of factorial combinations of two tomato cultivar. (TI 106 and TI 539), three irrigation intervals (5, 10 and 15 days) and three plant densities (27750, 55500 and 83250 plants/ha) arranged in split-plot design, with combinations of irrigation interval and plant density allocated to the main plots and the varieties to the sub-plots. The subplot size was 1.5 x 3.0m in dimension i.e. 4.5m^2 gross area.

3.3 Tomato Varieties.

Variety TI 106 is well adapted to the northern Guinea savanna. The fruit is pear-shaped and plant is determinate to semi-determinate (Anonymous, 1993b).

TI 539 is among the newly introduced lines. Its fruit is cylindrical in shape and very firm. The plant is determinate and the fruit very fleshy, with less water content, than var. TI 106. It is a processing tomato, which has been found to tolerate high temperatures Anonymous, 1993b).

3.4 Cultural Practices

3.4.1 Nursery preparation and managements.

Nursery beds of 1.0m width were prepared, for raising the tomato seedlings. Seeds were sown on 25th October, 1994 (for the 1994/95 dry season trial) and on 27th October, 1996 (for the 1995/96 dry season trial). Before sowing the seeds about 25g/m^2 of N.P.K. (15:15:15) was incorporated into the nursery beds. Seeds were drilled in 15cm apart and lightly covered with soil. The beds were then mulched and watered using a watering can. As soon as seedlings emerged, the mulch materials were removed and re-arranged between the rows. The beds were watered regularly and kept weed-free, until seedlings were ready for transplanting.

3.4.2 Land preparation and transplanting.

The experimental fields were disc-ploughed and harrowed before making rows of sunken beds of 1.5 x 3.0m sizes. The beds were bounded by low bunds in order to retain the irrigation water. The seedlings were transplanted on 10th December, 1994 for 1994/95 and on 12th December for the 1995/96 dry season trial. In both years seedlings were transplanted at the age of 6 weeks after sowing at 60 x 60cm for 27750 plants/ha, 60 x 40cm for 55,500 plants/ha and 40 x 30cm for 83, 250 plants/ha.

3.4.3 Fertilizer application.

The crop received an application of N.P.K. (15:15:15) fertilizer at the equivalent rate of 45kg/ha of N, 20kg/ha P and 37kg/ha K at one week after transplanting. Additional 65kg of N/ha was applied as side-dressing in two equal split doses. The first half was applied at 3 weeks after transplanting and the remaining half at 6 weeks after transplanting.

3.4.4 Weed control.

Weeds on the experimental plots were controlled through manual weeding at about 3,6 and 9 weeks after transplanting, by means of a hand hoe.

3.4.5 Pest and disease control.

During both the 1994/95 and 1995/96 dry seasons, there were no serious pest and diseases problems. However, a regime of three fortnightly spraying was carried out against fruit worm (Helicoverpa spp) attack, using Cymbush at the rate of 30 - 40mls per 20 litres of water.

3.4.6 Irrigation method.

The experimental fields were irrigated by surface flooding method. The variable irrigation interval treatments were imposed as from two weeks after transplanting.

3.4.7 Harvesting.

Matured and ripe fruits were harvested manually at weekly intervals. The harvested fruits from each plot were counted and weighed. The period of harvesting lasted for six weeks. At each harvesting fruits were sorted out into marketable and unmarketable classes.

3.5 Soil Analysis.

Samples of soil from the experimental site were taken at depths of 0-15cm and 15-30cm before transplanting. The composite samples for each depth range was analysed for physical and chemical characteristics. Details of these are presented in Appendix I for the 1994/95 and 1995/96 dry seasons.

3.6 Observations Recorded.

A random sample of three plants per plot was taken at 6, 8 and 10 weeks after transplanting (WAT) and from this the following variables were determined plant height, number of leaves per plant, leaf area index (LAI), leaf dry weight, number of branches per plant, stem dry weight and number of flowers per plant. The average values for the samples were recorded for analysis.

3.6.1 Plant height

The height of plant was measured from the base to the terminal bud of the main stem, with the aid of metre rule.

3.6.2 Number of leaves per plant

The number of leaves per plant was recorded as the average number of leaves from the three plant samples.

3.6.3 Leaf area index (LAI).

This was recorded for only the 1995/96 dry season trial. Leaf area index (LAI) was determned by modified Watson's method (Watson, 1958). Three plants were randomly selected from each plot. Their leaves were detached and separated on the basis of size difference. A representative leaf from each size group was traced on a graph sheet and its area determined by counting squares covered by leaves. Those leaves, along with the remaining leaves in the sampled plants, were dried in an oven at a constant temperature of 70°C for 48 hours. Measurements of weights were taken for the dried traced leaves and the remaining leaves in the sample separately. The leaf area (LA) of the sample was calculated using the formula:

$$LA = \frac{W \times M}{Y} \times Z$$

where W = weight of traced leaves in grams.

M = weight of remaining leaves in the sample

Y = mean traced leaf weight in grams

Z = traced leaf area in m^2

The leaf area index (LAI) was obtained thus:

$$LAI = \frac{LA}{SA.}$$

Where LA = Leaf area.
SA = Appropriate area on the ground in (m^2).

3.6.4 Leaf dry weight per plant.

The leaves from another set of sampled plants were removed and oven dried to a constant weight before final weights were determined and average values were calculated to obtain leaf dry weight/plant.

3.6.5 Number of branches per plant.

The number of primary branches (those arising from the main stem) of each of the three tagged plants/plot was determined and the average values recorded.

3.6.6 Stem dry weight per plant.

The stems from sampled plants were removed and oven dried to a constant weight before final weights were recorded. Average values were taken to determine the average stem dry weight per plant.

3.6.7 Number of flowers per plant.

The flowers on the tagged plants were counted and average value determined to arrive at the mean number of flowers per plant. This was done at 6 and 8 weeks after transplanting.

3.6.8 Mean weight per fruit at harvest.

The total number and weight of mature fruits from each plot were recorded at each harvest. The cumulative fruit weight divided by their total number per plot gave the mean weight per fruit.

$$\text{Mean weight per fruit at harvest} = \frac{\text{Total fruit wt/plot}}{\text{Total number of fruit/plot}}$$

3.6.9 Fruit yield per plant.

The total cumulative harvested fruit weight per plot divided by number of plant stands per plot.

3.6.10 Total fruit yield per hectare (t/ha).

Total fruit yields per plot were converted to tonne per hectare basis, using the appropriate conversion factor.

3.6.11 Proportion of unmarketable fruits.

At each harvest, mature fruits which were considered to be unmarketable (rot-affected) were culled and counted per plot. The proportion of the unmarketable fruits was determined as follows; total number of unmarketable fruits/plot divided by the total number of fruits per plot.

3.7 Statistical Analysis of Data.

The data collected were subjected to statistical analysis of variance (F-test) as described by Snedecor and Cochran (1967), to test the significance of treatment effects. The treatment means were then compared using the Duncan's Multiple Range Test (DMRT), wherever the F-test was significant (Duncan, 1955).

CHAPTER FOUR

4.0 RESULTS

4.1 Plant Height.

The mean plant height of tomato during the 1994/95 and 1995/96 dry season trials as influenced by treatments are shown in Tables 1 and 2, respectively. In both the trials, the results had the same pattern. Variety TI 106 plants were significantly taller than those of TI 539 at all the sampling periods. Increaseing irrigation interval from 5 to 15 days led to successive significant reductions in plant height at 6 WAT. At 9 and 10 WAT, however, the crops with 15 days irrigation interval had significant reduction in plant height compared to crop irrigated at 5 and 10 days interval which were similar in height. Increasing plant density from 27750 to 83250 plants/ha significantly increased plant height at all the sampling stages in both trials except at 6 and 10 WAT in the 1995/96 trial, where higher plant populations of 55500 and 83250 plants/ha produced plants of similar height.

A significant interaction between variety and plant density on plant height at 8 WAT during the 1995/96 dry season was observed (Table 3). Increasing plant density from 27,750 to 55,500 plants/ha significantly increased plant height in both varieties. But a further increase in plant density to 83,250 plants/ha had no significant influence on TI 106, only the height of TI 539 was significantly increased.

Table 1. Effect of variety, irrigation interval and plant density on plant height(cm) of tomato during the 1994/95 dry season.

	Weeks after transplanting (WAT)		
Treatment	6	8	10
Variety (V)			
TI 106	20.8a	32.5a	37.4a
TI 539	17.7b	27.6b	32.4b
SE ±	0.07	0.11	0.16
Irrigation interval (days) (I).			
5	19.7a	32.4a	36.7a
10	19.2b	31.9a	36.00a
15	18.9c	26.0b	31.5b
SE ±	0.05	0.15	0.21
Plant density (D) (plants/ha)			
27,750	18.8c	27.0c	31.5c
55,500	19.3b	31.0b	35.0b
83,250	19.7a	32.1a	37.2a
SE ±			
Interactions			
D x I	NS	NS	NS
V x I	NS	NS	NS
V x D	NS	NS	NS
D x V x I	NS	NS	NS

Means followed by the same letter(s) within a column of a same treatment group are not statistically different using Duncan's Multiple Range Test (P= 0.05).

NS = Not significant.

Table 2: Effect of variety, irrigation interval and plant density on plant height (cm) tomato during the 1995/96 dry season.

	Weeks after transplanting (WAT)		
Treatment	6	8	10
Variety (V)			
TI 106	18.1a	29.9a	23.5a
TI 539	15.6b	24.9b	29.5b
SE +	0.38	0.11	0.14
Irrigation interval (days) (I)			
5	17.8a	29.6a	33.9a
10	15.9b	29.2a	33.6a
15	14.4c	23.6b	29.4b
SE ±	0.13	0.16	0.18
Plant density/ha (D) (plants/ha))			
27,750	16.4b	25.5c	29.8b
55,500	18.9a	27.4b	31.5a
83,250	18.9a	29.7a	32.1a
SE ±	0.13	0.23	0.25
Interactions			
D x I	NS	NS	NS
V x I	NS	NS	NS
V x D	NS	**	NS
D x V x I	NS	NS	NS

Means followed by the same letter(s) within a column of treatment group are not statistically different using Duncan's Multiple Range test (P = 0.05).

NS = Not significant
** = Significant differences at P= 0.01.

Table 3: Interaction of variety and plant density on plant height (cm) at 8 WAT during the 1995/96 dry season.

	Variety	
Treatment	TI 106	TI 539
Plant density (plants/ha)		
27,750	27.5c	24.4e
55,500	29.4a	26.3d
83,250	29.9a	28.3b
SE ±	0.21	

Means followed by the same letters) within a column of treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

4.2 Number of Leaves per Plant.

The effects of treatments on the number of leaves per plant during the 1994/95 and 1995/96 dry seasons are shown in Tables 4 and 5, respectively. In both years, variety TI 539 generally produced significantly lower number of leaves than TI 106 at all the sampling periods.

Increasing irrigation interval from 5 to 10 days had no significant effect on leaf number except at early sampling period of 6 WAT. Increasing irrigation interval from 10 to 15 days, however, led to a significant reduction in leaf number at all the stages of sampling.

The successive increase in plant density resulted in significant reduction in leaf number, except at 6 WAT in the 1994/95 trial when the difference between 27750 and 55500 plants/ha was not significant. Similarly, the difference between 55500 and 83250 plants at 10 WAT in the 1995/96 trial was also not significant. Interactions among factors were not significant.

4.3 Leaf Area Index (LAI)

The data on leaf area index was recorded only for the 1995/96 trial. The response of leaf area index to treatments is shown in Table 6. A significant difference in leaf area index (LAI) between the two varieties was observed at all the sampling periods. Variety TI 106 had significantly higher leaf area index than TI 539.

A significant decrease in leaf area index was observed in response to increasing the irrigation interval from 5 to 10 days at 6 WAT. At 8 and 10 WAT, increasing irrigation interval from 5 to 10 days produced similar leaf area index. But a further increase in irrigation interval to 15 days significantly reduced LAI at all stages of sampling. The successive increase in plant density from 27,750 to 83,250 plants/ha at 6 and 8 WAT led to significant increases in leaf area index. But at 10 WAT increasing plant density only up to 55,500 plant/ha increased leaf area index. Interaction among factors were not significant.

4.4 Number of Branches per Plant.

The effects of the treatments on number of branches per tomato plant during the 1994/95 and 1995/96 dry seasons are shown in Tables 7 and 8, respectively. Variety TI 106 produced significantly higher number of branches than did TI 539 at all the sampling periods. Extending irrigation interval significantly reduced number of branches per plant in both 1994/95 and 1995/96 dry season. However, the differences between 5 and 10 day irrigation intervals at 10 WAT in the 1994/95 dry season and at 8 and 10 WAT in the 1995/96 dry season were not significant. Increasing plant density from 27750 to 55500 and further to 83250 plants/ha resulted in a significant decrease in number of branches per plant at 6 and 8 WAT in 1994/95 and at 6 WAT in the 1995/96 trial. However, at 10 WAT in 1994/95 and at 8 and 10 WAT in 1995/96 dry seasons there was no significant difference, in number of branches/plant, between the higher planting densities of 55500 and 83240 plants/ha. There were no significant interactions among factors tested.

Table 4: Effect of variety irrigation interval and plant density on number of leaves per plant during the 1994/95 dry season.

	Weeks after transplanting (WAT)		
Treatment	6	8	10
Variety (V)			
TI 106	31.3a	44.1a	71.4a
TI 539	26.8b	38.4b	59.0b
SE ±	0.16	0.4b	59.0b
Irrigation interval (days) (I)			
5	31.1a	45.1a	70.7a
10	29.0b	44.5a	70.3a
15	27.2c	34.6b	55.4b
SE ±	0.20	0.19	0.15
Plant density (D) (plants/ha)			
27,750	29.8a	44.6a	70.4a
55,500	29.5a	40.4b	64.3b
83,250	28.3b	38.8c	60.9c
SE ±	0.27	0.26	0.15
Interactions			
DxI	NS	NS	NS
VxI	NS	NS	NS
VxD	NS	NS	NS
DxVxI	NS	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range test (P=0.05).

NS = Not significant.

Table 5: Effect of variety, irrigation interval and plant density on number of leaves per plant during the 1995/96 dry season.

Treatment	Weeks after transplanting (WAT) 6	8	10
Varieties (V)			
TI 106	28.7a	40.2a	65.8a
TI 539	23.0b	35.2b	47.4b
SE ±	0.16	0.6	0.28
Irrigation interval (days) (I)			
5	28.0a	41.4a	63.4a
10	27.1b	40.9a	63.0a
15	25.4c	29.7b	49.2b
SE ±	0.12	0.20	0.30
Plant density (D) (Plants/ha)			
27,750	28.1a	40.9a	64.2a
55,500	26.8b	36.8b	58.2b
83,250	25.7c	34.3c	57.5b
SE ±	0.19	0.27	0.29
Interactions			
DxI	NS	NS	NS
VxI	NS	NS	NS
VxD	NS	NS	NS
DxVxI	NS	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

NS = Not significant.

Table 6: Effect of variety, irrigation interval and plant density on leaf area index per plant of tomato during the 1995/96 dry season.

Treatment	Weeks after transplanting		
	6	8	10
Variety (V)			
TI 106	0.9a	1.5a	1.8a
TI 539	0.5b	1.1b	1.1b
SE ±	0.003	0.0023	0.003
Irrigation interval (days) (I)			
5	0.9a	1.1a	1.1a
10	0.7b	1.1a	1.6a
15	0.5c	0.9b	1.0b
SE ±	0.003	0.0024	0.0048
Plant density(D) (plants/ha)			
27,750	0.4c	0.5c	0.7b
55,500	0.8b	1.3b	1.8a
83,250	1.1a	1.4a	1.8a
SE ±	0.004	0.003	0.006
Interactions			
DxI	NS	NS	NS
VxI	NS	NS	NS
VxD	NS	NS	NS
DxVxI	NS	NS	NS

Means followed by the same letter(s) within a column of a same treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

NS = Not significant.

Table 7: Effect of variety, irrigation interval and plant density on number of branches per tomato plant during the 1994/95 dry season.

	Weeks after transplanting		
Treatment	6	8	10
Variety (V)			
TI 106	5.2a	7.9a	10.2a
TI 539	4.3b	6.1b	7.6b
SE ±	0.12	0.13	0.11
Irrigation interval (days) (I)			
5	5.2a	8.1a	10.6a
10	4.7b	7.1b	9.9a
15	4.2c	5.9c	6.4b
SE ±	0.4	0.14	0.21
Plant density (D) (plants/ha)			
27,750	5.4a	8.8a	10.9a
55,500	4.7b	6.7b	8.9a
83,250	4.1c	5.9c	7.8b
SE ±	0.14	0.20	0.28
Interactions			
DxI	NS	NS	NS
VxI	NS	NS	NS
VxD	NS	NS	NS
DxVxI	NS	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Rang Test (P=0.05).

NS = Not significant.

Table 8: Effect of variety, irrigation interval and plant density on number of branches per tomato plant during the 1995/96 dry season.

Treatment	Weeks after transplanting		
	6	8	10
Variety (V)			
TI 106	3.9a	5.6a	7.2a
TI 539	3.4b	4.2b	4.9b
SE ±	0.10	0.15	0.09
Irrigation interval (days) (I)			
5	3.7a	5.9a	7.4a
10	3.3b	5.6a	7.1a
15	2.8c	3.4b	4.1b
SE ±	0.11	0.10	0.29
Plant density (D) (plants/ha)			
27,750	3.8a	6.5a	7.9a
55,500	3.5b	4.4b	5.6b
83,250	3.1c	3.9b	4.9b
SE ±	0.12	0.18	0.22
Interactions			
D x I	NS	NS	NS
V x I	NS	NS	NS
V x D	NS	NS	NS
D x V x I	NS	NS	NS

Means followedby the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

NS = Not significant.

4.5 Leaf Dry Weight.

The effects of treatments on leaf dry weight per tomato plant during the 1994/95 and 1995/96 dry seasons are shown in Tables 9 and 10. Variety TI 106 produced significantly higher leaf dry weight than did TI 539 at 6, 8 and 10 WAT, during both seasons. Increasing the irrigation interval from 5 to 10 days had no significant effect on leaf dry weight except at 6 WAT, when dry weight of leaves declined. However extending the irrigation interval to 15 days significantly reduced leaf dry weight at all sampling periods.

Varying plant density from 27750 to 55500 plants/ha significantly reduced leaf dry weight at all the periods of sampling. A further increase in plant density to 83250 plants/ha, however, significantly reduced leaf dry weight only at 6 and 10 WAT in the 1994/95 trial and at 6 WAT in the 1995/96 trial. There were no significant interactions observed among treatment factors on the leaf dry weight.

4.6 Stem Dry Weight

Tables 11 and 12 show the influence of treatments on stem dry weight during the 1994/95 and 1995/96 dry seasons, respectively. At all the sampling periods of 6, 8 and 10 WAT, variety TI 106 produced more stem dry weight than did TI 539 in both seasons.

Increasing irrigation interval from 5 to 15 days had no significant effect on stem dry weight except at 6 WAT of the 1995/96 trial when stem dry matter was reduced. However a further increase in irrigation interval to 15 days significantly reduced stem dry weight except at 6 WAT during the 1994/95 dry season, when the reduction was not significant.

Variation in plant density had no significant effect on the stem dry weight at 6 WAT in 1994/95 dry season. However, significant reduction in stem dry weight was observed as a result of increase in plant density from 27750 to 55500 plants/ha, at 8 and 10 WAT in the 19954/95 and at 6, 8 and 10 WAT in 1995/96 dry season. The differences in stem dry weight between 55500 and 83250 plants/ha were not significant, except at 6 WAT in the 1995/96 trial, when stem dry weight was significantly reduced.

Table 9: Effect of variety, irrigation interval and plant density on leaf dry weight (g) per tomato plant during the 1994/95 dry season.

	Weeks after transplanting		
Treatment	6	8	10
Variety (V)			
TI 106	8.5a	17.9a	28.7a
TI 539	7.4b	14.4b	19.9b
SE ±	0.06	0.07	0.16
Irrigation interval (days) (I)			
5	8.2a	18.3a	26.9a
10	7.9b	17.5a	26.7a
15	7.2c	12.9b	19.5b
SE ±	0.06	0.15	0.18
Plant density (D) (plants/ha)			
27,750	8.2a	18.6a	27.6a
55,500	7.9b	15.1b	23.5b
83,250	7.6c	14.6b	21.9c
SE ±	0.05	0.18	0.25
Interactions			
D x I	NS	NS	NS
V x I	NS	NS	NS
V x D	NS	NS	NS
D x V x I	NS	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

NS = Not singificant.

Table 10: Effect of variety, irrigation interval and plant density on leaf dry weight (g) per tomato plant during the 1995/96 dry season.

	Weeks after transplanting (WAT)		
Treatment	6	8	10
Variety (V)			
TI 106	6.6a	14.5a	24.5a
TI 539	4.7b	10.9b	15.6b
SE ±	0.02	0.07	0.15
Irrigation interval (days) (I)			
5	6.8a	15.9a	22.7a
10	6.5b	15.7a	22.2a
15	6.3c	9.3b	15.9b
SE ±	0.04	0.08	0.20
Plant density (D) (plants/ha)			
27,750	6.8a	16.6a	23.1a
55,500	4.5b	11.5b	19.4b
83,250	4.2c	11.4b	18.6b
SE ±	0.05	0.20	0.27
Interactions			
D x I	NS	NS	NS
V x I	NS	NS	NS
V x D	NS	NS	NS
D x V x I	NS	NS	NS

Means followedby the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P= 0.05).

NS = Not significant.

Table 11: Effect of variety, irrigation interval and plant density on stem dry weight (g) per tomato plant during the 1994/95 dry season.

Treatment	Weeks after transplanting		
	6	8	10
Variety (V)			
TI 106	1.9a	7.6a	11.6a
TI 539	1.0b	5.5b	8.8b
SE ±	0.31	0.06	0.25
Irrigation interval (days) (I)			
5	2.0a	7.6a	11.6a
10	1.3a	7.2a	11.6a
15	1.37a	4.9b	7.9b
SE ±	0.37	0.11	0.28
Plant Density (D) (plants/ha)			
27,750	1.4a	8.7a	12.4a
55,500	1.9a	5.9b	9.4b
83,250	1.3a	5.6b	8.9b
SE ±	0.45	0.12	0.36
Interactions			
D x I	NS	*	NS
V x I	NS	NS	NS
V x D	NS	NS	NS
D x V x I	NS	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P= 0.05).

NS = Not significant
* = Significant differences at P = 0.05.

Table 12: Effect of variety, irrigation interval and plant density on stem dry weight(g) per tomato plant during the 1995/96 dry season.

Treatment	Weeks after transplanting		
	6	8	10
Variety (V)			
TI 106	1.3a	5.2a	8.9a
TI 539	0.9b	3.7b	6.6b
SE ±	0.006	0.04	0.10
Irrigation interval (days) (I)			
5	1.2a	4.8a	9.3a
10	1.2b	4.7a	9.1a
15	1.2c	3.4b	4.9b
SE ±	0.005	0.13	0.08
Plant density (D) (plants/ha)			
27,750	1.2a	6.2a	9.2a
55,500	1.2b	3.3b	7.3b
83,250	1.2c	2.9b	6.8b
SE ±	0.005	0.14	0.15
Interactions			
D x I	NS	NS	*
V x I	NS	NS	NS
V x D	NS	NS	NS
D x V x I	NS	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P= 0.05).

NS = Not significant
* = Significant differences at (P=0.05)

The significant plant density and irrigation interval interaction on stem dry weight per tomato plant as shown in Tables 13 and 14 in the 1994/95 and 1995/96 trials at 8 and 10 WAT respectively, revealed that at fixed irrigation intervals of 5 and 10 days the increase in plant densityfrom 27750 to 55500 plants/ha significantly reduced stem dry weight. The difference between 55560 and 83340 plants/ha was not significant at the irrigation intervals of 5 and 10 days. It was only when the irrigation interval was increased to15 days that increasing plant density from 55500 to 83250 plants/ha that led to further significant reduction in weight. Plant density of 27750 plants/ha at 5 and 10 days irrigation intervals produced the highest stem dry weight, while 83250 plants/ha at 15 days irrigation interval recorded the least stem dry weights in both seasons.

Table 13: Interaction of plant density and irrigation interval on stem dry weight (g) per tomato plant at 8 WAT during the 1994/95 dry season.

	Plant density (plants/ha)		
Treatment	27750	55500	83250
Irrigation interval (days)			
5	9.7a	6.7bc	6.2cd
10	9.4a	6.3cd	6.0d
15	7.0b	4.7e	2.9f
SE ±	0.19		

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

Table 14: Interaction between plant density and irrigation interval on stem dry weight(g) per tomato plant at 8 WAT during the 1995/96 dry season.

Treatment	Plant density (plants/ha) 27750	55500	83250
Irrigation interval (days)			
5	11.0a	8.7b	8.2bc
10	10.7a	8.3bc	7.9c
15	7.1d	4.8e	3.0f
SE ±	0.14		

Means followed by the same letter(s) within a column of a same tretment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

4.7 Number of Flowers per Plant.

The effects of treatments on the number of flowers per tomato plant during the 1994/95 and 1995/96 dry seasons are shown in Tables 15 and 16 respectively. Variety TI 106 had significantly higher number of flowers than TI 539 in both trials. Significant reduction of number of flowers was recorded at 6 WAT as a result of extending irrigation interval from 5 to 10 and further to 15 days in both seasons. At 8 WAT, the difference between 5 and 10 days irrigation intervals was not significant but at the longer irrigation interval of 15 days, the number of flowers per plant was significantly reduced. The difference between 55500 and 83250 plants/ha was, however, not significant except at 6 WAT during the 1995/96 season.

There were no significant interactions observed among treatment factors on the number of flowers per plant.

4.8 Mean Weight per Fruit.

The values of mean weight per fruit during the 1994/95 and 1995/96 dry seasons as influenced by the treatments, are shown in Table 17. Fruit of variety TI 539 significantly out weighed that of TI 106 during both seasons. The mean fruit weight under irrigation intervals of 5 and 10 days significantly was higher than the mean weight per fruit recorded under the 15 days irrigation interval. The effect of varying plant density was also significant. In both trials, significant reduction in mean weight per fruit was observed, when the plant density was increased from 27750 to 55500 plants/ha. However, further increase in plant density to 83250 plants/ha had no significant effect on mean weight per fruit.

4.9 Fruit Yield per Plant

The data on fruit yield per plant in both 1994/95 and 1995/96 dry season trials as influenced by treatments are presented in Table 18. Variety TI 106 had significantly higher yield per plant than TI 539. Increasing irrigation interval from 5 to 10 days showed no significant effect on fruit yield per plant, but a further increase to 15 days significantly depressed fruit yield per plant in both years. The effect of plant density was also significant. Increasing plant density from 27,750 to 55,500 plants/ha significantly reduced fruit yield per plant. But the effect of the further rise in plant density from 55500 plants/ha to 83250 plants/ha had no significant effect on fruit yield per plant during both the dry season trials. There were no significant interactions observed among treatment factors on the fruit yield per plant.

Table 15: Effect of variety, irrigation interval and plant density on number of flowers per tomato plant during the 1994/95 dry season.

Treatment	Weeks after transplanting 6	8
Variety (V)		
TI 106	18.3a	29.8a
TI 539	17.8b	25.6b
SE ±	0.09	0.1
Irrigation interval (days) (I)		
5	18.9a	29.6a
10	18.4b	29.4a
15	17.7c	24.6b
SE ±	0.086	0.08
Plant density (D) (plants/ha)		
27,750	19.1a	30.1a
55,500	18.1b	27.1b
83,250	17.67b	26.9b
SE ±	0.19	0.15
Interactions		
D x I	NS	NS
V x I	NS	NS
V x D	NS	NS
V x V x I	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Rang Test (P =0.05).

NS = Not significant.

Table 16: Effect of variety, irrigation interval and plant density on number of flowers per tomato plant during the 1995/96 dry season.

Treatment	Weeks after transplanting	
	6	8
Varieties (V)		
TI 106	15.4a	25.9a
TI 539	13.4b	20.8b
SE ±	0.06	0.11
Irrigation interval (days) (I)		
5	15.0a	26.2a
10	14.4b	25.9a
15	17.7c	21.8b
SE ±	0.06	0.09
Plant density (D) (plants/ha)		
27,750	16.5a	26.6a
55,500	15.4b	23.7b
83,250	13.4c	23.2b
SE ±	0.07	0.18
Interactions		
D x I	NS	NS
V x I	NS	NS
V x D	NS	NS
D x V x I	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05)

Table 17: Effect of variety, irrigation interval and plant density on Mean weight per fruit (g) during the 1994/95 and 1995/96 dry seasons.

	Fruit weight (g)	
Treatment	1994/95	1995/96
Variety (V)		
TI 106	29.9b	24.7b
TI 539	30.5a	27.4a
SE ±	0.07	0.06
Irrigation interval (days) (I)		
5	31.9a	28.7a
10	31.5a	28.5a
15	27.4b	24.5b
SE ±	0.14	0.09
Plant density (D) (plants/ha)		
27,750	32.8a	29.5a
55,500	29.4b	28.2b
83,250	28.9b	28.0b
SE ±	0.21	0.01
Interactions		
D x I	NS	NS
V x I	NS	NS
V x D	NS	NS
D x V x I	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P= 0.05).

NS = Not significant.

Table 18: Effect of variety, irrigation interval and plant density on fruit yield per tomato plant (kg) during the 1994/95 and 1995/96 dry seasons.

	Fruit yield/plant (kg)	
Treatment	1994/95 Dry	1995/96
Variety (V)		
TI 106	0.9a	0.6a
TI 539	0.7b	0.4b
SE ±	0.01	0.01
Irrigation interval (days) (I)		
5	0.9a	0.6a
10	0.9a	0.6a
15	0.6b	0.3b
SE ±	0.01	0.01
Plant density (D) (plants/ha)		
27750	1.1a	0.8a
55500	0.6b	0.4b
83250	0.6b	0.3b
SE ±	0.01	0.02
Interactions		
D x I	NS	NS
V x I	NS	NS
V x D	NS	NS
D x V x I	NS	NS

Means followed by the same letter(s) within a column of a same treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

NS = Not significant.

4.10 Total Yield per Hectare.

Total fruit yield per hectare (t/ha) during the 1994/95 and 1995/96 dry seasons as influenced by treatments are shown in Table 19. Variety TI 106 produced significantly higher total fruit yield than TI 539, during both the dry season trials. Irrigation intervals of 5 and 10 resulted in a similar fruit yield per hectare. However both were significantly higher than value obtained under the longer irrigation interval of 15 days.

Increasing plant density from 27750 to 55500 plants/ha, significantly increased fruit yield, while a further increase to plant density of 83250 plants/ha produced non significant increase in yield during both seasons.

In the 1995/96 trial, a significant interaction between plant density and irrigation interval on total fruit yield/ha was observed (Table 20). At fixed irrigation intervals of 5, 10 and 15 days, significant increase in fruit yield was observed in response to increase in plant density up to 55500 plants/ha. A further increase in plant density beyond 55500 plants/ha had no significant effect, at 5 and 10 days irrigation interval. But at the longer irrigation interval of 15 days a further increase in plant density beyond 55500 plants/ha significantly reduced yields. However at fixed plant densities of 27750, 55500 and 83250 plants/ha increase in irrigation interval from 5 to 10 days produced similar yields, but further increase to 15 days irrigation interval significantly reduced yield.

Table 19: Effect of variety, irrigation interval and plant density on total fruit yield (t/ha) during the 1994/95 and 1995/96 dry seasons.

Treatment	Total fruit yield (t/ha) 1994/95	1995/96
Variety (V)		
TI 106	24.4a	21.4a
TI 539	16.1b	13.4b
SE ±	0.12	0.09
Irrigation interval (days) (I)		
5	23.6a	21.2a
10	23.5a	20.9a
15	13.9b	11.4b
SE ±	0.11	0.19
Plant density (D) (plants/ha)		
27,750	16.0b	13.3b
55,500	22.9a	20.6a
83250	23.3a	21.3a
SE ±	0.18	0.26
Interactions		
D x I	NS	*
V x I	NS	NS
V x D	NS	NS
D x V x I	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P=0.05).

NS = Not significant

* = Significant at P = 0.05.

Table 20: Interaction of plant density and irrigation interval on total fruit yield (t/ha) of tomato during the 1995/96dry season.

Treatment	Plant density (plants/ha) 27750	55500	83250
Irrigation interval (days)			
5	14.2c	23.0ab	23.6a
10	13.7c	22.2b	22.5ab
15	8.4f	10.4e	8.2f
SE ±	0.32		

Means followed by the same leter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Rang Test (P=0.05)

4.11 Proportion (%) of Unmarketable Fruit.

The proportions of unmarketable, rot affected fruits during the 1994/95 and 1995/96 dry season trials as influenced by treatments are shown in Table 21. Variety TI 106 significantly recorded higher proportion of unmarketable fruits than TI 539. Irrigation interval had significant effects on the proportion of unmarketable fruits. Extending irrigation interval from 5 to 15 days, significantly decreased unmarketale fruits during both trials. Similarly, increasing plant density from 27750 to 83250 plants/ha significantly reduced proportion of unmarketable fruits, although at 55500 and 83250 plants/ha were at par in the 1995/96 dry season. Interactions among factors were not significant.

Table 21: Effect of variety, irrigation interval and plant density on the proportion (%) of unmarketable fruits during both the 1994/95 and 1995/96 dry seasons.

	Proportions of unmarketable fruits (%)	
Treatment	1994/95	1995/96
Variety (V)		
TI 106	10.a	8.3a
TI 539	9.2b	7.4b
SE ±	0.05	0.05
Irrigation interval (days) (I)		
5	10.3a	9.5b
10	9.5b	7.5bc
15	8.0bc	6.6c
SE ±	0.08	0.10
Plant density (D) (plants/ha)		
27,750	10.4a	8.6a
55,500	9.7b	7.8b
83250	8.8c	7.1b
SE ±	0.15	0.22
Interactions		
D x I	NS	NS
V x I	NS	NS
V x D	NS	NS
D x V x I	NS	NS

Means followed by the same letter(s) within a column of a treatment group are not statistically different using Duncan's Multiple Range Test (P= 0.05).
NS = Not significant.

Correlation Analysis.

The result of the correlation analysis among the various growth and yield parameters of tomato during the 1994/95 and 1995/96 dry seasons are shown in Tables 22 and 23 respectively. During 1994/95 dry season, there were strong positive correlations (P=0.01) between total fruit yield (t/ha) and fruit yield per plant (r=0.93), plant height (r=0.89), number of branches per plant (r=0.35) and stem dry weight (r=0.82). Total yield was also positively correlated with mean fruit weight (r=0.27), leaves dry weight per plant (r=0.21) and number of flowers per plant (r=0.28) at 5% level of significance.

However, during the 1995/96 dry season, there were highly positive correlations (P=0.01) between tomato yield (t/ha) and all the growth and yield characters except leaf area index (r=0.24). Highly and positive correlation (P=0.01) was observed between tomato mean fruit weight and all growth and yield characters in both years except plant height (r=0.13) in 1994/95 and LAI (r=0.21) in 1995/96 where no significant relationship was observed.

Leaves dry weight was also observed to be highly and positively correlated (P=0.01) with number of main branches per plant, stem dry weight and number of flowers per plant, number of leaves/ plant, plant height, fruit yield and mean fruit weight during the 1994/95 and 1995/96 dry seasons. However there was no significant relationship between the leave dry weight and leaf area index (r=0.17) in 1995/96 dry season.

During the 1994/95 and 1995/96dry season trials, the number of main branch per plant were found to be highly and positively correlated (P=0.01) with the stem dry weight (r=0.76 and 0.88) and number of flowers per plant (r=0.72 and 0.92) respectively. Similarly the stem dry weight was also observed to be highly and positively correlated (P=0.01) with the number of flowers per plant (r=0.90 and 0.78) during the 1994/95 and 1995/96 dry season respectively.

Leaf area index was found to be highly and positively correlated (P=0.01)with number of flowers per plant (r=0.37). But a significant and positive correlation (P=0.05) exist between leaf area index and number of branches per plant (r=0.33). However, there was no significant correlation between leaf area index and stem dry weight (r=0.06) during the 1995/96 dry season trial.

Table 22: Simple correlation coefficients among growth and yield parameters of tomato grown during the 1994/95 dry season.

	1	2	3	4	5	6	7	8	9
1.	1.00								
2.	0.27	1.00							
3.	0.93**	0.85**	1.00						
4.	0.88**	0.13NS	0.09NS	1.00					
5.	0.31*	0.80**	0.91**	0.30*	1.00				
6.	0.27*	0.77**	0.88*	0.40*	0.94**	1.00			
7.	0.35**	0.55**	0.68**	0.48**	0.74**	0.77**	1.00		
8.	0.82**	0.82**	0.89**	0.35**	0.93**	0.96**	0.71**	1.00	
9.	0.28*	0.71**	0.82**	0.47**	0.89**	0.88**	0.73**	0.90**	1.00

Foot Note:
1. Total fruit yield
2. Mean fruit weight
3. Fruit yield per plant
4. Plant height at 10 WAS.
5. Number of leaves per plant at 10 WAT.
6. Leaf dry weight per plant at 10 WAT
7. Number of branches per plant at 10 WAT.
8. Stem dry weight per plant at 10 WAT.
9. Number of flowers per plant at 8 WAT.

Degree of freedom (df =52)
* = Significant at (P=0.05)
** = Significant at (P = 0.05)
NS = Not significant.

Table 23: Simple correlation coefficients among growth and yield parameters of tomato grown during the 1995/96 dry season.

	1	2	3	4	5	6	7	8	9	10
1.	1.00									
2.	0.99**	1.00								
3.	0.95**	0.96**	1.00							
4.	0.40**	0.41**	0.47**	1.00						
5.	0.37**	0.37**	0.39**	0.85**	1.00					
6.	0.97**	0.91**	0.94**	0.41**	0.44**	1.00				
7.	0.24NS	0.20NS	0.28*	0.85**	0.73**	0.17NS	1.00			
8.	0.95**	0.96**	0.99**	0.51**	0.42**	0.94**	0.33**	1.00		
9.	0.94*	0.94*	0.89**	0.33*	0.33*	0.91**	0.06NS	0.88*	1.00	
10.	0.86**	0.88**	0.92**	0.52**	0.48**	0.83**	0.37**	0.92**	0.78**	1.00

Foot Note:

1. Total fruit yield
2. Mean fruit weight
3. Fruit yield per plant
4. Plant height at 10 WAT
5. Number of leaves per plant at 10 WAT
6. Leaf dry weight per plant at 10 WAT.
7. Leaf Area Index at 10 WAT.
8. Number of branches per plant at 10 WAT.
9. Stem dry weight plant at 10 WAT.
10. Number of flowers per plant at 8 WAT.

Degree of freedom (df= 52)

* = Significant at (P = 0.05)
** = Significant at (P = 0.01)
NS = Not significant.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Varietal Effects

Significant differences were observed in growth characters between the two varieties, with variety TI 106 being more vigorous in terms of height,number of leaves per plant, leaf area index, number of branches per plant, leaf dry weight, stem dry weight and number of flowers per plant than TI 539. These observations seem to confirm the earlier description of variety TI 106 being more of a semi-determinate rather than determinate type (Quinn, 1980). While variety TI 539 was described as being small statured, more compact tomato plant than TI 106 (Ibrahim, 1994).

Although variety TI 539 produced larger sized fruits than variety TI 106, the higher mean fruit yield from a higher number of fruits per plant produced by variety TI 106 invariably, resulted to its yielding more than variety TI 539 in term of total fruit yield/ha. This shows that production of fewer and larger fruit size by TI 539 was not enough to compensate for the higher fruit number of moderate size produced by TI 106. This confirm the result earlier reported by Ibrahim (1994)where he reported that variety TI 106 as being higher yielding than variety TI 539.

Variety TI 106 had more proportion of fruits that were unmarketable (rot affected) compared with TI 539. This might be due to the fact that fruits of TI 539 are normally more firm and more tolerant to injury than TI 106, (Anon, 1993b).

5.2 Effect of Irrigation Interval

Extending irrigation interval from 5 to 15 days significantly depressed growth parameters, especially at the early stage of growth (6WAT). However, increasing irrigation interval from 5 to 10 days had no significant effect on growth components (at 8 and 10 WAT), as well as yield components. A further increase to 15 days interval significantly reduced both growth and yield parameters. This indicates that beyond the ten-day interval, the available moisture in the root zone has begun to be inadequate for optimum growth. Water is very essential nutrient necessary for the stimulation of rapid vegetative growth, because of its importance in photosynthesis, respiration and other metabolic process. Similar observations were observed by Salter (1958) and Caliandro (1971) who reported that a reduction in vegetative growth, number and size of fruits were observed as a result of increasing irrigation interval.

The proportion of unmarketable (rot affected) fruits was significantly higher at 5 days irrigation interval than at 10 and 15 days irrigation intervals. This observation could be associated to too wet condition created by frequent irrigation (5 days interval) which encourage fruit rot. This result agrees with the findings of Amans (1992) who reported that proportion of unmarketable fruits increased with increase in irrigation frequency.

5.3 Effect of Plant Density

All the growth parameters of the tomato examined responded significantly to change in plant density, except stem dry weight at 6 WAT in the first season. Plant height was apparently increased with increase in plant density, however at later stages of growth (8 and 10 WAT) the differences between the plant densities of 55,500 and 83,250 plants were not significant indicating that the level of interplants competition at the higher plant densities had no negative effect on plant height. The initial positive response of height to increasing plant density was most likely due to intense competition for space and solar radiation by the plants at high density. Plants in crowded condition become more elongated or etiolated in growth. This observation is in agreement with the reports of several other workers who observed significant increase in plant height under condition of increasing plant density. (Petrukhina and Belaya 1986 and Papadopoulos, 1988). Similarly, leaf area index was also observed to be significantly increased as a ressult of increasing plant density from 27,750 to 83,250 plants/ha, although the difference between 55,500 and 83250 plants/ha was not significant at the later stages of growth (8 and 10 WAT). This increase in leaf area in response to increasig plant density is more likely because of increase in number of plant per unit area and, thus, more number of leaves per unit area.

Positive responses were observed on the plant height and leaf area index to plant density increased, however other growth parameters such as number of leaves per plant, leaf and stem dry weights, and number of branches and flowers per plant responded negatively to increasing plant density beyond 27,750 plants/ha. Similar responses were obtained for mean fruit weight and fruit yield per plant. This response could be associated with increasing intensity of competition for plant growth factors such as soil water and nutrients, solar radiation and space at higher plant densities. At low density of 27750 plants/ha, individual plant had sufficient supply of these growth factors which resulted in greater values of these growth and yield parameters. While at higher plant densities of 55500 and 83250 plants/ha, more intense inter-plant competrition reduced the availability of these growth factors and therefore, resulted in a reduction in both growth and yield. These results agree with the finding of Petruckhina and Lambeth (1986) who reported that increasing plant density reduced vegetative growth as well as the yield.

Total fruit yield per hectare however, responded positively to increasing plant density from 27,750 to 83,250 plants/ha, although 55,500 and 83,250 plants/ha gave similar yield. This increase in total fruit yield (t/ha) in response to plant density was due to the greater number of plants and therefore, more number of fruits per hectare. Similar observations were reported by Gapinki (1971), Hisatomi (1972) and Adelana (1976) who reported that increasing plant density, increased fruit yield per hectare.

Increasing plant density from 27,750 to 83,250 plants/ha, reduced the proportion of unmarketable (rot affected) fruits. The cause of fruit rot in the present experiment was not adequately investigated, but most of the affected fruits have symptoms of either fruit worm attack and sunscald. It could be possible that the dense foliage cover, resulting from close planting, offered the fruits some significant degree of protection against sunscald and attack by the fruitworm. These results agree with the finding of Hassan (1978) who reported that high planting density minimized the proportion of fruits that are discarded at harvest due to rot.

5.4 Interactions

The interaction between variety and plant density was significant on plant height. While the increasee in plant density from 55500 to 83250 had no significant effect on TI 106, but the height of TI 539 was significantly increased. In this work the possible reason for an increase in plant height in response to increasing plant density is being attributed to etiolation under crowded situation. In this case, variety TI 539 seems to be more sensitives to over-population than TI 539. This may be because TI 539 is a smaller statured plant than TI 106. In an earlier experiment, involving variety evaluation, it had been recommended that many of the small statured tomato varieties could be grown under higher plant densities (Quinn, 1980).

There were significant interaction between irrigation interval and plant density in respect to stem dry weight and fruit yield/ha. In all of these growth and yield characters, the increase in plant density from 55,500 to 83,250 plants/ha had no significant effects if the irrigation interval is maintained between 5 and 10 days. Significant adverse changes in growth or yield attributes were observed as a results of increase in density from 55,500 to 83,250 plants/ha only when the irrigation interval was increased above 10 days to 15 days . These observations showed that when moisture supply was limited by the long irrigation interval (over 10 days), then increasing plant density above 55,500 plants/ha resulted to significant reduction in growth and yield. On the other hand, such adverse effect due to high plant density was not obvious when adequate water supply was provided through shorter irrigation interval. The combination of irrigation intervals of 5 and 10 days with 55,500 plants/ha gave good yields as when combined with the highest density of 83,250 plants/ha. But a longer irrigation interval was detrimental to yield irrespective of the plant density. This result agrees with the findings of Hemado and Orihuel (1979) who reported that water stress generally reduced plant growth and fruit development.

5.5 Correlation

The significant and positive correlation(P=0.01) that existed between tomato fruit (t/ha) and all the growth and yield parameters except leaf area index (LAI) which was not significant during the 1995/96 dry season revealed that the parameters examined are the critical determinants of tomato yield. This is because as the growth related parameters increases in size, the yield and yield parameters also increases. All growth and yield parameters in both years were significantly and positively correlated (P=0.01) with tomato mean fruit weight except plant height in 1994/95 dry season which was not significantly correlated. This is probably because of the competitive growth between fruit growth and increase in plant height which led to weakening the relationship between these parameters.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Field trials were carried out at the Institute for Agricultural Research (I.A.R) Ahmadu Bello University,Samaru Zaria, during the 1994/95 and 1995/96 dry seasons, to determine the response of two tomato (Lycopersicon esculentum Mill) cultivars to varying irrigation intervals and plant density.

The treatments consisted of two tomato varieties namelyTI 106 and TI 539, three irrigation intervals (5, 10 and 15 days) and three plant densities (27,750, 55,500 and 83,250 plants/ha) arranged in a split-plot design, with the combinations of irrigation interval and plant density allocated to the main plots and the varieties to the subplots. These were replicated three times.

Variety TI 106 was significantly superior to TI 539, in terms of plant height, number of leaves and branches per plant, leaf area index, leaf and stem dry weights and number of flowers produced. TI 106 also produced higher fruit yield per hectare and fruit yield per plant as well as proportion of unmarketable fruits (rot affected) than TI 539. TI 539 on the other hand, had significantly larger sized fruits than TI 106.

Increasing irrigation interval from 5 to 15 days significantly reduced growth parameters of the tomato cultivars especially at the early stage of growth (6 WAT). However the values of these growth parameters such as plant height, number of leaves per plant, leaf area index, leaf dry weight, number of branches per plant, stem dry weight and number of flowers per plant were found to be similar under 5 and 10 days irrigation interval. Total fruit yield/plant and mean weight/ fruit were also reduced as a result of increasing irrigation interval from 5 to 15 days, however 5 and 10 days irrigation recorded similar values however both have significantly higher values than those recorded at the higher irrigation interval of 15 days. Significant decrease in proportion of unmarketable fruits was observed as a result of increasing irrigation interval from 5 to 15 days, during both dry seasons.

Increasing plant density from 27,750 to 55,500 plants/ha significantly decreased, number of leaves per plant, leaf dry weight, leaf area index, number of branches and flowers per plant. However at the later stages of growth (8 and 10 WAT), further increase from 55,500 to 83,250 plants/ha had no significant effect on these growth parameters. Mean fruit weight, fruit yield per plant and proportion of unmarketable fruits were also significantly reduced by increasing plant density from 27,750 to 83,250 plants/ha, although 55,500 and 83,250 plants/ha gave similar values. Increasing plant density at early growth stage (6 WAT) led to a significant increase in plant height and leaf area index, but at later stages of growth (8 and 10 WAT), densities of 55,500 and 83,250 plants/ha recorded similar values. Increasing plant density from 27,750 to 83250plants/ha, significantly increased total fruit yield per hectare up to 55,500 plants/ha because further increase to 83250 plants/ha had no significant effect on total fruit yield (t/ha).

The interaction between variety and plant density was significant on plant height. In this case, variety TI 539 seems to be more sensitive to over-population than TI 106. There were significant interaction between irrigation interval and plant density on stem dry weight and fruit yield/ha. In all these growth and yield characters the increase in plant density from 55,500 to

83,250 plants/ha had no significant effect, when the irrigation interval is maintained at 5 and 10 days. Significant, adverse changes in growth or yield characters were observed as a results of increase in plant density from 55,500 to 83,250 plants/ha only when the irrigation interval was increased to 15 days.

Correlation studies on tomato yield (t/ha) during the 1994/95 dry season indicated a significant and positive correlation (P=0.01) between tomato yield (t/ha) and fruit yield per plant, plant height, Number of branches per plant and stem dry weight. During 1995/96 dry season significant and positive correlation (P=0.01) was observed between tomato yield (t/ha) and all growth and yield characters except leaf area index which was not significantly correlated to tomato yield (t/ha).

Based on the results obtained in this study, it could be suggested that the use of plant density of 82250 plants/ha in combination with a 5 days irrigation interval gave the best marketable yield of tomato at Samaru. Variety TI 106 was a better yielder than TI 539.

REFERENCES

Abdel Al. Z. E. (1973). The effects of plant population, irrigation frequency and cultivars on yield and cultivars on yield and canning qualities of tomatoes fruits grown under hot tropical condition. Third African Symposium of Horticultural Crops. University of Nairobi. Kenya. September, 1973. P. 193 - 199.

Adelana, B. O. (1976). The effect of plant density on tomato yields in Western Nigeria Sierra-Leone Agricultural Journal 3 (2): 31 - 34.

Adigun, J. A. (1991). Effect of intra-row spacing and nitrogen on response of tomato (Lycopersicon esculentum Mill) to weed interference and management in the Nigerian Savanna. Unpublished Ph.D. Thesis. Postgraeduate School Ahmadu Bello University, 144pp.

Alibury, F.D. and May, O.(1970). Irrigation schedule and production of processig tomatoes on California Agricultue 24 (8) 10 - 11.

Amable, R. A and Sinnadurai, S.(1977). The influence of potassium, calcium and irrigation treatment on tomato fruit quality Acta Horticulture. No 53, 166 - 170.

Amans, E. B. (1988). The yield response of determinate tomato cultivars to planting density at Kadawa in Sudan Savanna of Nigeria. Terminal Report orticultural Crop Research Programme. Institute for Agricultural Research, Zaria.

Amans, E. B. (1992). The yield response of tomatoes cultivar "Roma VF" to irrigation interval, plant density and mulching in the Nigerian Savanna. Terminal Report, Horticultural Crop Research Programme. Institute for Agricultural Research, Ahmadu Bello University, Zaria.

Amico, J. Dell, Je Rez, E. A. and Bukem. V. (1985). Response of tomato CV. L72 to moderate water deficit during different growth stages. Tropical Agriculture. 12 (4): 71 - 75.

Anonymous,(1987). Nutrient and irrigation requirement of tomatoes. Cropping scheme report. Irrigation Research Programme. Institute for Agricultural Research. Ahmadu Bello University, Zaria, Nigeria.

Anonymous, (1993a). Bulletin of statistics, 6 (4) 58 - 59. Food and Agricultural Organisation of United Nations. Rome, Italy.

Anonymous (1993b). Four heat tolernt tomato varieties. Approved recommendation. Institute for Agricultural Res. Samaru, Zaria.

Babalola, O. And Fawusi, M.O.A. (1980). Drought susceptibility of two tomato varieties (Lycopersicon esculentum Mill) Plant and Soil 55: 205 - 215.

Bryan, H. H. (1970). Plant populations and fertilizer effect on concentration of tomato yields for once over harvest on rectal soils. American Society for Horticultural Science. 14, 244-253.

Caliandro, H.H. (1971). The effect of the volume of water applied annually as a function of irrigation frequency on the yield of tomatoes. Rivista di Agronomia 51, 215-222.

Casarini, B. S. (1966). Experiments on irrigation by infiltration for tomatoes for processing. Indian Journal of Agriculture 31: 198 - 204.

Deidda, M. and Marras, G.(1973). Determining the interval and volume of watering for canning tomatoes as a functionof soil humidity. Horticultural Abstracts. 21, (2), 793 - 804.

Doss, B. D. (1973). Rates of Nitrogen and irrigation for tomatos. Journal American Society for Horticultural Science 100, (4): 435 - 437.

Duncan, D. B. (1958). Multiple range and multiple F. Test. Biometrics. 11, 1 - 42.

Erinle, I. D. (1989). Present status and propects for increased production of tomato and pepper in Northern Nigeria. Tomato and pepper production in the tropic proceedings of the Inernational symposium on integrated management practice. AVRDC. Shenhua. Tainan. P. 530 - 548.

Fapohunda, H. O. (1992). Irrigation frequency and amount for okra and tomato using a point source sprinkler system. Scientia. Horticultural 49 (2): 25 - 31.

Gapinski, M.(1971). The effect of spacing and hormone application on glass house tomato yield, Journal American Society for Horticultural Science. 96, 412 - 414.

Grubben, G.J.H. (1977). Tropical vegetables and their genetic resources. International Board for plant genetics 25 - 28.

Gupta, A. and Shukla, V.(1977). Response of tomato (Lycopersicon esculentum Mill) to plant spacing, nitrogen, phosphorous and potassium fertilization. Indian Journal of Horticulture 34 (3) 270 - 276.

Hamer, N and Olabi, R. (1985). The importance of cultivar and stand density in early tomato forcing. Acta Horticultural. No. 190; 459 - 465.

Hassan,M. S. (1978). Effect of Nitrogen fertilizer and plant density on yield and quality of tomato in the Sudan Gezira. Acta Horticultural. Horticultural Abstracts 49 (9) 588.

Hernado, V. and Orihuel, B. (1979). Effect of regime and fertilizer levels on the yield, quality of fruit size of winter - grown tomatoes, V. Effect of water regime on P and K of fruit quality. Proceedings of the International Seminar on Soil Environment and Fertility Management, Intensive Agriculture (SEFMIA0 p. 168 - 174.

Hisatomi, T. (1972). Studies on growth control during early forcing and cold season tomatoes. The effect of soil temperature, soil moisture, nitrogen supply and plant density on the growth and yield of tomatoes. Bulletin of Nara Agriculture Experimental Station No.4 27 -35.

Ibrahim, R. (1994). Response of three tomato (Lycopersicon esculentum Mill) varieties to nitrogen and phoshorous fertilizer levels. Unpublished, M.Sc. Thesis, Department of Agronomy, Ahmadu Bello University, Zaria.

Kwapata, M. B. (1991). Response of contrasting tomato cultivars to depth of applied mulch and irrigation frequency under hot dry tropical conditions. Tropical Agriculture, (Trinidad) 68 (3): 301 - 363.

Martin, P. E. (1966). Irrigation of tomatoes in a single harvest programme. California Agriculture 20: 12 - 14.

Mohammed, S. F. and Ali, Z. E. (1986). Effect of row-plant spacing and levels of nitroen fertilizer on yield and quality of direct-seeded tomatoes. Acta Horticultural No. 190 459- 465.

Moore, J. N. Kattan, A. A. and Fleming, J.W. (1958). Effect of supplementary irrigation, spacing and fertility on yield and quality of processing tomatoes. Proceedings American Society Horticultural Science 71; 359 - 368.

Moses, S. A. (1995). Effects of phosphorous, potassium and irrigation frequency on the growth and yield of tomato (Lycopersicon esculentum Mill). Unpublished B. Sc. Project. Report, Faculty of Agriculture. Ahmadu Bello University, Zaria. 50 - 51.

Nasser. H. H. (1986). Effect of planting pattern, plant population and nitrogen level on yield quality of tomato. Acta Agricultural. No. 190; 435 - 442.

Nwadukwe, P. O. (1986). Tomato root growth and distribution as affected by irrigation frequency and ground water table depth. Unpublished M. Sc.Thesis. School of Postgraduate Studies Ahmadu Bello University, Zaria.

Papadopoulos, A. P. (1988). Plant spacing effects on photosynthesis and transpiration of the greenhouse tomato. Canadian Journal of Plant Science. 68: 1206.

Petruckhina, N. I. and Belaya, T. V. (1986). Effect of plant density on fruit yield and quality of tomatoes direct sown on hills. Acta Agriculture No. 190, 423 - 429.

Phene, O.J., K.R. Devias, R.L. Maccormic, R. B. Hunmacher and J. D. Pierro, (1989). Water-fertility management for surface drip irrigated tomatoes. In tomato and pepper Production in Tropics. Proceedings of the International Symposium on Integrated Managemen Practics (AVRDC), Shenhua, Tainan p. 323 - 338.

Postiglione, L. and Lanza. A, (1978). Plant density and nitrogen fertilization in the production of tomatoes for mechanical harvesting. Horticultural Abstracts 49; (6),373.

Purseglove, J. W. (1968). Tropical crops Dicotyledons. 2nd ed. Longman Publication. Hong Kong, pp 719.

Quinn, J. G. (1971). Factor affecting the productionn of tomatoes for the processing industry during different seasons in the Northern States of Nigeria. Unpublished M. Sc. Thesis, School of Postgraaduate Studies, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria.

Quinn, J. G. (1980). A review of tomato cultivar trials in Northern States of Nigeria. Samaru Miscellaneous Paper, 84. Institute for Agricultural Research, Ahmadu Bello University, Zaria.

Rice, L. W. and H.D. Tindall (1986). Fruit and vegetable production in Africa. Oxford University Press, London U.K.

Rodriquez, B. P. and Lambeth, V.N. (1973). Artificial lighting and spacing as photosynthetic and yield factoring winter greenhouse culture. Journal of the American Society for Horticultural Science.

Sakiyama, R. (1968). Effect of irrigation, temperatures and shading on acidity of tomato fruits. Journal of the Japanese Society for Horticultural Science 37: 67 - 72.

Salter, P. J. (1958). The effect of different water regimes on the vegetative growth and fruit development in tomato. Journal of the Japanes Society for Horticultural Science 33; 1 - 11.

Seno, S. and Kimoto, T. (1989). Influence of increasing plant density on productivity and other agronomic characteristics of three processing tomato cultivars. Cientifica, 17; 7 - 13.

Smith, C. B.; K. T., Ferrti, P. A, and Orzolak, M. D. (1992). Plant density as related to fertilizer needs for processing and fresh market tomatoes. Horticultural Abstracts 63; (3), 251.

Snedecor, G. W. and Cochran, W. G. (1967). Statistical Methods 6th edition. Iowa State University Ames. 456pp.

Snyder, R. G. and Bauelre, W. L. (1985). Watering frequency and media volume effect on growth, water status, yield and quality of greenhouse tomatoes. Horticultural Science Abstracts 20: (2): 205 - 207.

Watson, D.J. (1958). The estimation of leaf area in field crops. Journal of Agricultural Science 27: 474 - 483.

Zaharan,M. and Tamm, H, (1973). Influence of plant density on growth, nutrient composition, yield and quality of mechanically- harvested tomatoes. Journal of American Society for Horticultural Science 98; 513 -516.

Zerbi, G. M. (1974). The effect of irrigation frequency on the quantitative and qualitative characteristics of processing tomatoes. Journal of American Society for Horticultural Science 79; 414 - 418.

Appendix I: Physical and chemical properties of soils of the experimental site during the 1994/95 and 1995/96 dry seasons.

	1994/95		1995/96	
	Soil depth (cm)		Soil depth (cm)	
Soil characteristic	0-15	15-30	0-15	15-30
Chemical properties				
pH in water(1:2.5)	5.3	5.65	5.65	5.8
pH in $CaCl_2$ (1:2.5)	4.5	4.6	4.6	4.85
Organic carbon (%)	0.58	0.54	0.54	0.51
Total nitrogen (%)	0.07	0.08	0.08	0.055
Available phosphorus (ppm)	3.67	3.81	3.80	3.32
Exchangeable bases (meq/100g)				
Ca	3.27	3.52	3.51	2.68
Mg	0.94	0.81	0.81	0.75
K	0.31	0.28	0.28	0.24
Na	0.13	0.12	0.12	0.09
CEC	5.99	5.78	5.78	5.42
Physical properties				
Sand (%)	41	39	39	40
Silt (%)	43	45	45	42
Clay (%)	16	16	16	18
Textural class	Loam	Loam	Loam	Loam

Appendix II: Mean rainfall maximum and minimum temperature, relative humidity at monthly interval during the period of the experiment 1994/95 dry season.

Month	Rainfall (mm)	Temperature (°C)		Relative-humidity (%)	
		Max.	Min.	10.00am	4.00pm
1994					
October	6.9	30.6	19.0	76.4	65.0
November	-	30.1	13.0	35.6	38
December	-	27.0	11.1	37.0	26.0
1995					
January	-	28.19	10.5	31.4	21.2
February	-	30.5	13.3	27.7	19.6
March	-	35.8	18.4	26.3	29.8
April	8.3	36.2	19.4	41.2	17.7

Source: Meteorological Unit, Institute for Agricultural Research, Ahmadu BelloUniversity, Samaru, Zaria, Nigeria.

Appendix III: Mean rainfall, maximum and minimum temperature, relative humidity at monthly interval during the period of the experiment 1995/96 dry season.

Month	Rainfall (mm)	Temperature (^oC)		Relative humidity (%)	
		Max.	Min.	10.00am	4.00pm
1995					
October	13.2	32.0	19.0	74.3	54.6
November	-	28.4	15.6	43.70	37.9
December	-	32.9	14.1	20.7	21.1
1996					
January	-	32.4	10.3	23.6	16.5
February	-	33.4	17.0	23.9	16.5
March	-	37.7	20.8	31.7	30.7
April	-	27.4	23.0	55.8	31.7

Source: Meteorological Unit, Institute for Agricultural Research Ahmadu Bello University,Samaru, Zaria, Nigeria.

BIOGRAPHY

NAME	RILWANU DAYI UMAR
DATE OF BIRTH:	30THE DECEMBER, 1958
PLACE OF BIRTH:	DAYI
STATE OF ORIGIN:	KATSINA STATE
BUSINESS ADDRESS:	DEPARTMENT OF AGRICULTURE AND IRRIGATION ENGINEERING HASSAN USMAN KATSINA POLYTECHNIC. KATSINA.
	OR
	c/o ALHAJI UMAR DAYI MALUMFASHI DISTRICT HEAD OFFICE, MALUMFASHI.

SCHOOL ATTENDED AND DATE

Primary School, Dayi	1968 - 1973
Government Secondary School Malumfashi	1973 - 1978
School of Basic Studies, Zaria.	1979 - 1980
Ahmadu Bello University, Zaria	1980 - 1984

POST HELD SINCE AWARD OF FIRST DEGREE

Master Grade II (NYSC) Government Secondary School Gumbi, Sokoto State	1984 - 1985
Master Grade II Government College Katsina	1985 - 1987
Lecturer III Department of General Studies, Hassan Usman Katsina Poly.	1987 - 1989
Lecturer II Department of General Studies, HUK Poly	1989 - 1992
Lecturer I, Department of Agriculture and Irrigation Engineering, Hassan Usman Polytechnic.	1992 - date

Year of Admission for Post-graduate: 1994.

Admission Number: M.Sc/Agric./04976/1993 - 94.