EFFECT OF CROP SPACINGS ON GROWTH AND YIELD OF FOUR TOMATO (*Lycopersicon lycopersicum* Karst) VARIETIES UNDER RAINFED AND IRRIGATED CONDITIONS.

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A Thesis submitted to the Postgraduate School Ahmadu Bello University. Zaria in Partial fulfilment of the requirement for the Degree of Doctor of Philosophy in Agronomy.

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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 before in any previous application for a higher degree.

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DEDICATION

To my Mum

ACKNOWLEDGEMENT

I wish to express my profound gratitude to Dr. E.B. Amans, my major supervisor, Head of Agronomy Department and Dean, Faculty of Agriculture, for the valuable guidance and contributions during the course of this study. The same sincere gratitude is extended to Professor M.K. Ahmed who jointly supervised and made valuable contributions in the preparation of this thesis; and also to late Professor I.D. Erinle for his assistance during the initial stage of this study.

Sincere appreciation is also extended to my technical assistant Mallam Ibrahim Danyaro; my senior collegues Drs. A.M. Falaki, S.A. Dadari, B. Tanimu and L. Aliyu; my friends S. Miko, I.U. Abubakar, M. Mahmud, Auwal, Sayyadi, Jahun, Garba, Suleiman and many others too numerous to mention. Appreciation is also extended to S. Idris and N. Abraham who typed this manuscript.

My unfailing gratitude also goes to my brothers notably Mahmud, Aminu and Balarabe and to my sister Fatima and her kids notably Hassan and Hussaini and to all members of the Sarkin Bichi Family.

Finally, I wish to extend my sincere gratitude to the entire members of Horticultural Crops Research Programme of the Institute for Agricultural Research, the University Board of Research (UBR) and National Agricultural Research Project (NARP) for the cooperation and assistance I recieved during the conduct of this work.

RUFA'I IBRAHIM (1999)

ABSTRACT

Four field trials were carried out. two during rainy seasons of 1995 and 1996 and two others during dry seasons of 1995/96 and 1996/97. at the Institute for Agricultural Research Farm. Samaru. Zaria (11 ll'N: 07° 38'E and 686m above sea level). The objective was to study the effect of inter- and intra-row spacing levels on four varieties of tomato (*Lycopersicon lycopersicum* Karst). The treatment consisted of factorial combinations of three inter and three intra-row spacing levels (45, 60 and 75cm; and 30. 45 and 60cm. respectively) and four tomato varieties (TI 106. TI 182. TI 468 and TI 539 representing Roma VF, Early Mech. 3900 and 5-80-285. respectively). A split plot design was used in which the factorial combinations of inter and intra-row spacings were allocated to the main plots while the tomato varieties were allocated in the subplots, with the treatments replicated four times.

The results showed that the tomato plants were generally taller, had higher total dry matter (TDM), attained earlier days to 50% flowering and days to first harvest as well as heavier fruits when grown in the wet seasons than in the dry seasons. However, the number of leaves per plant, leaf area index (L A I). yield/plant and total fruit yield per hectare were higher during the dry seasons than in the wet season. Relative growth rate (RGR), net assimilation rate (NAR) and percent soluble solids were not affected significantly by the seasonal changes. Number of flowers/plant was similar in three trials with the exception

of 1996/97 dry season where the flower number was higher. Fruit firmness was also similar in all trials with the exception of 1995/96 dry season were the fruits were softer.

In all four seasons of the trial, variety TI 468 had the tallest plants, higher TDM, RGR, percent soluble solids and average weight/fruit compared with the other three tomato varieties. TI 106 and TI 539 had the highest number of leaves/plant, LAI, number of flowers/ plant, fruit firmness and yield/plant followed by TI 182, while TI 468 recorded the least value in most of these parameters. The NAR was highest in TI 106. followed by TI 182. TI 468 and TI 539 in that order. Days to 50% flowering and days to first harvest were significant only during the dry season with TI 106 attaining flowering and maturity similarly and much earlier than TI 539, TI 468 and TI 182 which were at par with each other. Total fruit yield per hectare was highest in TI 539 followed by TI 106 which, in turn was higher than TI 182 and TI 468 which recorded the least yield in all the trials.

Decreasing both inter and intra-row spacings from 75 to 45cm and 60 to 30cm, respectively, increased plant height (in 1995/96 only). LAI, NAR, percent soluble solids and total fruit yield per hectare. However, increasing both inter- and intra-row spacings from 45 - 75cm and 30 - 60cm, respectively, increased number of leaves/plant (wet seasons), days to 50% flowering (dry seasons), days to first harvest (dry seasons) fruit firmness (dry seasons) and yield/plant.

Correlation analysis showed positive and significant associations between fruit yield per hectare and most of the parameters studied except number of days to 50% flowering which was significantly and negatively correlated to fruit yield per hectare. Indirect contribution of most characters to fruit yield was greatest through number of leaves per plant and yield/plant. Plant height and yield/plant made the highest individual contributions to yield; while the combinations of plant height and number of leaves per plant and average fruit weight and yield/plant were the highest contributors to yield.

Polynomial responses of fruit yield to inter and intra-row spacings were both quadratic.

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CHAPTER ONE

1.0 INTRODUCTION

Tomato (Lycopersicon lycopersicum Karst) belongs to the family Solanaceae. It is currently the most important commercial vegetable grown in Nigeria. Large scale tomato production in Nigeria is mainly under irrigation during the dry season (September - March) when temperatures are mild and humidity moderate. The rainfed crop (June-September) is also important due to continous demand for fresh tomato, but generally limited by pests and diseases that are prevalent under such humid and warm conditions (Quinn, 1980). The area of major production is the northern part of the country, between latitude 8^0 - 13^0 N, but the greatest market is mostly in the south and other neighbouring countries (Amans *et al., 1986*).The crop stays for up to 3 months in the field and yields between 20 - 50t/ha. The period between March - June is normally too hot for successful tomato production.

Despite the above limiting factors, tomato production has continued to expand in Nigeria because of the increasing demand for fresh market tomato, the establishment of several large scale irrigation schemes and processing industries such as Vegfru Nigeria Plc and Cadbury Nigeria Plc.

Current production recommendations meant to improve output of tomato to meet the increasing demands include planting at 60 x 60 cm (inter- and intra-row spacings, respectively) on beds and 75 x 60cm on ridges approximating to plant densities of 27,778 and 22,222 plants/ha, respectively. But as pointed out in earlier

works, the appropriate crop spacing would vary with the phenotypic differences among tomato varieties (Quinn, 1980). Since the existing recommendations were made in the early Eighties, many new tomato varieties have been released recently.

Apart from environmental factors limiting tomato production, inadequate use of improved cultural methods such as correct spacings, fertilizers, pest and disease control measures also contribute to poor yields. In order to increase tomato production, efforts are being made to screen and develop tomato varieties that are more tolerant to higher population densities. Research work has identified some tomato lines with this feature, and that can yield better than our existing commercial cultivars (Quinn 1980, Amans *et al*, 1986). Response to cultural practices has often varied with cultivars. There is need for more information on this in order to determine the degree and importance of such variations. Adequate cultural practice such as correct spacing levels (inter- and intra-row) must be provided for the crop to express its full yield potential. Environmental requirements (e.g. seasonal differences) of a crop may also vary among the varieties or cultivars (Anonymous, 1985, Ibrahim, 1994). It is in view of these reasons that the present study was conducted with the following objectives:-

1. To study the effect of inter- and intra-row spacings on the growth and yield of four tomato varieties .
2. To study the interactions between the tomato varieties and crop spacing levels under both rainfed and irrigated conditions.
3. To recommend the spacing levels that will give optimum growth and yield of the tomato varieties.
4. To recommend the tomato varieties which gives the maximum fruit yield in either of the seasons.

CHAPTER TWO

2.0 LITERATURE REVIEW

The optimum inter and intra-row spacing levels that give maximum yield and good crop performance in the field depends on the crop cultivar, different climatic and adaptive conditions, resource availability and management practices (Quinn, 1980).

2.1 Effect of Inter-row Spacing on Growth and Yield of Tomato

Yakovenko (1978) reported that wider inter-row spacings ranging from 100-160cm resulted in significant decreases in yield, height, leaf area index and relative growth rate of tomato using the tomato cultivars Donetskii and Kievskii. However, number of leaves per plant and total dry matter were reported to be higher at the wider than closer inter-row spacings.

Postiglione and Lanza (1978) reported that when tomato cultivar Roma was planted at inter-row spacing of 45, 60 and 75cm with the intra-row spacing kept constant at 30cm, the total fruit yield per hectare was reduced as the inter-row spacing was increased but the mean fruit weight and yield/plant increased. The number of days to 50% flowering and to first harvest were longest at the closest inter-row spacing of 45cm. In another trial with tomato cultivars Roma VFN, CAL-J and CV-82, inter-row spacings of 30, 60 and 75cm were compared. The mean yield of marketable fruits was highest at the widest inter-row spacing (78.7t/ha) and declined (70t/ha) at the closest inter-row spacing (Seno and Kimoto, 1989). A similar trend to marketable yield was observed with regard to mean fruit weight and productivity per

plant. Roma VFN was the highest yielding cultivar followed by CAL-J. Number of flowers/plant was not affected by the different inter-row spacing levels.

2.2 Effect of Intra-row Spacing on Growth and Yield of Tomato.

Amans (1988) reported that in a 3 year trial with three tomato varieties, Roma VF, Early Mech and Ronita, decreasing intra-row spacing from 60 to 15cm increased the fruit yield/hectare, but with no significant difference in yield between 15 and 30cm intra-row spacing. The average fruit yield/plant, mean fruit weight and number of leaves/plant were highest at 60cm intra-row spacing. Plant height and leaf area index were higher at the close intra-row spacings of 15 and 30cm than at wider spacing.

In field trials carried out at 3 locations on four tomato cultivars (Harvestar, Pusa Early Dwarf, Ife No.1 and Ibadan Local), the intra-row spacing was kept constant at 75cm while the intra-row spacing was varied at 30, 45, 60 and 75cm. The result showed that the highest fruit yield/ha was obtained from the closest intra-row spacing of 30cm and the least yield from the widest spacing of 75cm (Adelana, 1976). Total dry matter was however, higher at the wider intra-row spacings, but the net assimilation rate was highest at the closest spacing. Number of flowers/plant was not significantly affected by the intra-row spacing levels.

Moldoveanu (1977) reported that using the determinate tomato cultivar Pioneer 2 and the indeterminate cultivar Export 2

planted at 15 and 30cm intra-row spacings, earliness (days to 50% flowering and days to first harvest) was enhanced in both cultivars by the closest intra-row spacing of 15cm. The cultivar Pioneer 2 matured earlier, produced more number of flowers per plant, had lower total dry matter and also had a higher percentage of marketable fruits/hectare at the closer intra-row spacing than Export 2.

Dimri and Gulshan (1988) reported that keeping inter-row spacing constant at 60cm and increasing the intra-row spacing from 30 to 60cm reduced the fruit yield/ha of cultivar Pant Bahar. Mean fruit weight was however, not affected by the change in intra-row spacing, but yield per plant was increased when intra-row spacing was increased from 30cm or 45cm to 60cm. The fruits were also more firm at the wider intra-row spacing of 60cm. In a similar trial using the tomato cultivar, HS-102 where the inter-row spacing was constant at 60cm, with intra-row spacing varied at 45, 60 and 75cm, the highest yield was obtained at the closest spacing of 45cm followed by 60cm (Bhatnagvar and Pandita, 1979). Anserwadekar *et al*(1980) reported that tomato cultivar 'Sioux' produced the highest yield of 113.5t/ha at an intra-row spacing of 25cm compared with a yield of 99.8t/ha obtained at 50cm spacing.

2.3 Inter-row x intra-row spacings interactions.

Lopez and Chang (1974) reported that when tomato plants were planted at inter-row spacings of 120, 150 and 180cm and intra-row spacings of 15, 30 and 45cm, yield decreased with wider spacings.

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Effect of Crop Spacings on growth and yield of four tomato (Lycopersicum (Karst) varieties under rainfed and Irrigated conditions / by Rufa'i Ibrahim. — Zaria: Dept. of Agronomy, ABU, 1999
xxiii, 189 leaves: ill. diagr., table.
Thesis (Ph.D) Ahmadu Bello University 199
Bibliography: leave 181–184.

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both inter and intra, but fruit size and average fruit weight increased appreciably. They recommended a spacing of 120 x 15cm. In a 3-year trial with the early tomato cultivar 'Planters', the plants were spaced at 70, 100, 130 and 150cm inter-row and 20 and 30cm intra-row. The highest average yield (109.6t/ha) with no adverse effect on fruit weight was obtained from the closest spacing combination of 70 x 20cm (Rodriguez and Frutos, 1976). Total dry matter was highest at the widest inter- and intra-row spacings.

In a two year trial with plants at various spacing combinations ranging between 30 x 30cm to 60 x 60cm, the leaf area index and fruit yield/hectare was highest at 30 x 30cm and lowest at 60 x 60cm (Joshi et al,1980). However, total dry matter and yield/plant were highest at 60 x 60cm spacings. In a trial with the tomato cultivar Solan Gola with the plants spaced at 90 x 30, 90 x 45 and 75 x 45cm, the closest spacing of 90 x 30cm gave the highest yield/hectare and the widest spacing of 90 x 45cm gave the highest yield/plant (Rastogi *et al*, 1978). Hassan (1978) reported that mean total yields for inter and intra-row spacings of 90 x 90, 90 x 75, 75 x 60 and 60 x 45cm were 42.4, 44.1, 59.6 and 60.9t/ha, respectively.

2.4 Inter-row spacing x variety interactions.

Rajewar and Patil (1979) reported that when tomato cultivars Marglobe, HS 10 and S12 were planted at inter-row spacings of 60 and 45cm plant height, number of leaves, total dry matter and flower number per plant differed little between cultivars and

inter-row spacing but fruit number/plant and fruit yield/plant were highest with HS101 and S12 at the widest spacing of 60cm. Yields/ha and leaf area index were highest with S12 at the closest inter-row spacing of 45cm. In another trial with tomato cultivars Pusa Ruby and NTDR-1 (indeterminate and semi determinate, respectively) spaced at 75 and 90cm inter-row spacing, the highest yields in both cultivars (60.3 and 56.0t/ha, respectively) were obtained from plants spaced at 90cm (Srinivasa *et al* , 1988).

2.5 Intra-row spacing x variety interactions.

Rajewar and Patil (1979) also reported that when the same three tomato cultivars Marglobe, HS 101 and S12 were planted at intra-row spacing of 60, 45 and 30cm plant height, number of leaves and total dry matter differed little between cultivars and the intra-row spacing levels but average fruit height, fruit number/plant and fruit yield/plant, were highest with HS 101 and S12 at the highest intra-row spacing of 60cm. Yields/ha and leaf area index were highest with S12 at the closest intra-row spacing of 30cm. Srinivasa *et al*, (1988) also reported that using the indeterminate cultivar Pusa Ruby and the semi determinate cultivar NTDR-1 spaced at intra-row spacings of 60, 50 and 40cm, highest yields/hectare were obtained from plants spaced at 50cm intra-row spacing.

Moldoveanu (1977) reported that using the determinate tomato cultivar Pioneer 2 and the indeterminate cultivar Export 2 planted at intra-row spacings of 30 and 15cm, Pioneer 2 gave the

highest percentage of standard fruits at the closer intra-row spacing of 15cm than Export 2

2.6 Correlation studies

Correlation deals with the association between pairs of variables independent of other variables under consideration. It is of great significance in determining the association of quantitative characters with yield for selecting characters that play an important role in influencing yield. Amans and Nwadukwe (1993) and Ibrahim (1994) reported a significant and very strong positive correlation between total fruit yield (t/ha) and yield/plant, mean fruit weight, number of flower/plant, leaf area index and plant height. A negative and strong correlation was observed between total fruit yield and days to 50% flowering.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

Replicated field experiments were conducted at the Institute for Agricultural Research (IAR) Farm Samaru (11^0 11'N, 07^0 38'E, 686m above sea level), to determine the response of four tomato varieties to varying inter and intra-row spacings in the Northern Guinea Savanna Ecological zone of Nigeria. The experiment was carried out during two rainy/wet seasons (1995 and 1996) and two dry seasons (1995/96 and 1996/97); the later as an irrigated crop. The soils of the experimental site were loam. Details of the physico-chemical properties of the soils taken for each of the four seasons as well as meteorological data for the period 1995 to 1997 are presented in Appendices I, II, III and IV.

3.2 Treatments and Experimental Design

Treatments consisting of four tomato varieties (Roma VF, Early Mech, 3900 line and 5-80-285), three inter-row spacings (45, 60 and 75cm) and three intra-row spacings (30, 45 and 60cm) were arranged in a split-plot design with four replications. The factorial combinations of inter-and intra-row spacings were allocated to the main plots while the tomato varieties were placed in the subplots. The subplot size was 3m x 3m ($9.0m^2$).

3.3 The Tomato Varieties

The tomato cultivar Roma VF (TI 106) is a well known and adapted cultivar in the Nigerian Savanna region. It is a

processing tomato with a pear-shaped fruit and a determinate to semi-determinate growth habit (Quinn, 1980).

Early Mech (TI 182) is also a processing tomato. The fruit is cylindrical in shape and the plant is semi determinate in growth habit.

3900 line (TI 468) is an introduced line. The fruit is round in shape and has high water and seed content than the other three varieties. It is a fresh table tomato (used in salad). The plant is indeterminate in growth habit.

5-80-285 (TI 539) is also among the introduced tomato lines from AVRDC (Asian Vegetable Research and Development Centre). The fruit is ovoid in shape, very firm, fleshy with high dry matter content and low seed content. It is a processing tomato, which has been found to tolerate high temperatures (Bodunde *et al*, 1993 and Ibrahim, 1994). The plant is determinate in growth habit.

The source of seeds for these varieties is the Institute for Agricultural Research, Samaru, Zaria.

3.4 Cultural practices

3.4.1 Nursery preparation and management.

Nursery beds of well pulverised soil were prepared for raising the seedlings. Before sowing about $25g/m^2$ of NPK 27: 13:13 was incorporated into the nursery soil. Seeds of the tomato varieties were sown on 9th June, 1995 and 24th May, for the 1995 and 1996 wet season trials, respectively; and on 2nd November, 1995 and 17th October, 1996 for the 1995/96 and 1996/97

dry season trials, respectively. The seeds were drilled in rows 15cm apart and lightly covered with soil. The nursery beds were then mulched with dry grass straw and watered to field capacity using a fine nozzled watering can. Subsequent watering was carried out regularly on daily basis.

After germination, the mulch material was removed and re-arranged between the rows of the growing seedlings.

3.4.2 Land preparation and planting

The experimental fields were disc-ploughed and harrowed before laying out the 3m wide beds on which the tomato seedlings are to be transplanted. In the rainy (wet) season trials, the beds were raised above the ground level to provide better drainage. However, during the dry seasons, the beds were slightly sunken, bounded by levees to facilitate better retention of irrigation water. Seedling growth and development was slightly faster during the rainy season. The seedlings were transplanted at five weeks after sowing (5 WAS) for the wet season trials and 6 WAS for the dry season trials.

During the dry season irrigation water was applied to the crops to meet up their water requirements. Pathways/waterways were provided between the subplots for irrigation. Each basin/plot was allowed to be filled with water before moving to the next plot. Water was applied at five weeks interval during the first three weeks and subsequently at 7 days interval. During the wet season the rains supplied the crops naturally with water.

3.4.3 Fertilizer application.

At transplanting an equivalent of 45kg/ha each of N, P and K, supplied as compound NPK 15:15:15 fertilizer, was applied as basal dressing. A further 65kgN/ha from urea fertilizer was supplied in two equal split applications at 3 and 6 weeks after transplanting (WAT) as top dressing.

3.4.4 Weed control.

Weeds were adequately controlled, using manual hoe-weeding. Three hoe-weedings were neccessary at about 3, 6 and 9 WAT of the tomato crop.

3.4.5 Disease and pest control.

To prevent foliar fungal diseases that are especially prevalent during the rainy season, a mixture of Benomyl (Benlate) and Dithane M45 at 2kg ai/ha was sprayed to the crops weekly starting from when they were five weeks old after transplanting.

3.4.6 Harvesting.

Matured fruits, as indicated by colour change from green to pink or reddish, were harvested at weekly intervals by manual hand picking.

3.5 Soil sampling and Analysis.

Soil samples were randomly taken from the experimental plots to a depth of 30cm each season before land preparation. The samples were dried and bulked for physical and chemical analyses. The properties of the analysed soil is shown in Appendix I. The texture was analysed by hydrometer method (Bouyoucos, 1951) and the textural class determined by the soil texture triangle (USDA,

1960). Soil pH was determined using the pH meter (Black, 1965). Organic carbon was measured by wet oxidation with dichromate as suggested by Wolf (1982). Total nitrogen was determined by the macro-Kjeldahl procedure (Bremmer, 1965). Available phosphorus was determined by the method described by Trough (1950). The extracted phosphorus was determined by the molybdate blue colours (Bray and Kurtz, 1945). Exchangeable cations were determined by the acetic acid method (Reith 1967). Magnesium, Calcium, Sodium and Potassium were determined by the atomic absorption spectrophotometry (Perkin Elmers Model 403).

3.6 Observations taken.

A sample of six plants, were taken at random and tagged per plot, were used to record the following parameters listed under 3.6.1 - 3.6.3. Other parameters recorded were either computed or recorded on plot and/or hectare basis.

3.6.1 Plant height.

The height of plant was determined in centimeter from the ground level to the terminal apex of the main branch. The data was recorded at 3, 6 and 9 WAT.

3.6.2 Number of leaves per plant.

This was taken also at 3, 6 and 9 WAT. The number of leaves on the tagged plants were counted and average taken.

3.6.3 Number of flowers per plant.

This was recorded at 5, 6 and 7 WAT. The number of flowers on the tagged plants were counted and average taken.

3.6.4 Total dry matter (TDM).

Three plant samples per plot were cut from their bases for dry matter determination, according to the recommendations of Hughes and Freeman (1967) and Radford (1967). The plants were chopped to pieces and oven dried at 70^0 C to a constant weight, recorded in grammes (g). This sampling was done at 3, 6 and 9 WAT.

3.6.5 Leaf Area Index (LAI).

The LAI is the assimilatory surface per unit ground area covered. The leaf area was determined by tracing method and was recorded at 3, 6 and 9 WAT. It was calculated using the formular given by Watson (1947 and 1952).

$$\text{Leaf Area Index (LAI)} = \frac{\text{Total leaf area}}{\text{Area of ground}}$$

3.6.6 Relative growth rate (RGR).

The RGR is the cumulative dry matter increment per unit of time. It was computed as described by Blackman (1919) and Briggs *et al* (1920). It was recorded at 6 and 9 WAT, using the TDM obtained under 3.6.4.

$$RGR = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

where W_1 and W_2 refers to the total plant dry matter at times t_1 and t_2, respectively.

3.6.7 Net assimilation rate (NAR).

The NAR represents the photosynthetic efficiency of assimilatory surfaces. It was computed using the formular suggested by Gregory (1926) and Watson (1947). This was also

recorded at 6 and 9 WAT.

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \frac{(\text{Log}_e L_2 \ \text{Log}_e L_1)}{(L_2 - L_1)}.$$

where W_1 and W_2 refers to total plant dry matter at times t_1 and t_2 where corresponding leaf area was L_1 and L_2 , respectively.

3.6.8. Days to 50% flowering.

This was recorded from the time of transplanting to when 50% of the plants in each plot had flowered.

3.6.9 Days to first picking (harvest) per plot.

This was also recorded from the time of transplanting to the time the fruits first showed ripening in each plot.

3.6.10 Fruit firmness.

This was recorded using a hand Durometer (Model '0-2') It measures how firm a fruit is in degrees (^{0}0). The sweep of the dial hand from zero to 100 is 265^0. The tomato fruit is pressed against pressure-sensitive point of the Durometer which registers the softness of the fruit in increasing degree of firmness. This data was recorded for a sample of five fruits per plot at four harvests and average taken per plot.

3.6.11 Percent soluble solids (%).

This was recorded using Refractometer. It measures soluble solids of fruits from 0-20%. This was also recorded for four harvests and the average taken.

3.6.12 Average fruit weight (g).

The average weight per fruit from each plot was determined as follows:-

$$\text{Average fruit weight} = \frac{\text{fruit weight per plot.}}{\text{fruit number per plot.}}$$

3.6.13 Fruit yield per plant (kg).

The mean fruit yield per plant was determined by dividing the plot yield by the number of plants per plot.

3.6.14 Total fruit yield (t/ha).

The mean fruit yield per hectare was extrapolated from total yield of fruits harvested from the net plots expressed in tons/hectare.

3.7 Statistical analysis of data.

All data collected were subjected to statistical analysis of variance using 'F' test as described by Snedecor and Cochran (1967). Multiple Comparison of the treatment means were done using the Duncan's Multiple Range Test, DMRT (Duncan, 1955). The main effects and interactions were determined for all characters in accordance with Gomez and Gomez (1984). The magnitude and type of relationship between the characters were assessed through simple correlation analysis (Little and Hills, 1978). The direct and indirect contributions and the percent contributions of the characters to total fruit yield were partitioned using the method of Dewey and Lu (1959). The polynomial response of the total fruit yield to factors tested were determined through a chi-square tested to ascertain which regression equation fits in best as suggested by Steel and Torrie (1984).

CHAPTER FOUR

4.0 RESULTS

4.1 WET SEASON TRIALS

4.1.1. Plant height.

Tables 1 & 2 show the effects of inter and intra-row spacings on the height of four tomato varieties during the 1995 and 1996 wet seasons, respectively. Generally, plant height ranged from 28.4cm at 3 WAT to 47.6cm at 9 WAT in 1995 and 24.1cm at 3 WAT to 48.6cm at 9 WAT in 1996. The four tomato varieties differ significantly in height at 6 and 9 weeks after transplanting (WAT) in 1995 and at all stages of growth in 1996. In both years variety TI 468 was the tallest followed by TI 106, which in most instances was statistically at par with varieties TI 182 and TI 539.

In both years plant height was not significantly affected by either the inter or the intra-row spacings at any stage of growth observed. Neither was any factor interaction found to be significant at any stage of observation in both wet seasons.

Table 1: Effect of inter- and intra-row spacings on plant height(cm) of four tomato varieties during the 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	29.4	41.8a	43.5b
TI 182	28.6	40.9a	42.3b
TI 468	33.7	43.7a	47.6a
TI 539	28.4	39.3b	42.9b
SE +	0.39	1.30	1.34
Inter-row spacings (cm)			
45	34.1	41.4	42.3
60	33.8	41.0	42.7
75	33.4	40.7	42.8
SE +	0.88	1.23	1.30
Intra-row spacings (cm)			
30	33.4	40.6	43.1
45	32.8	42.5	43.3
60	32.7	40.0	41.3
SE +	0.88	1.23	1.30
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 2: Effect of inter- and intra-row spacings on plant height(cm) of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	26.7b	33.2b	44.2b
TI 182	25.3b	33.0b	42.5b
TI 468	32.6a	37.1a	48.6a
TI 539	24.1b	34.5b	41.9b
SE ±	0.58	1.16	1.31
Inter-row spacings (cm)			
45	26.8	33.8	46.5
60	27.6	36.4	45.9
75	27.2	34.6	44.6
SE ±	0.36	1.98	1.00
Intra-row spacings (cm)			
30	27.0	36.1	46.1
45	27.4	35.4	46.1
60	27.1	34.0	45.5
SE ±	0.36	1.98	1.00
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.1.2. Number of leaves.

Varieties TI 106 and TI 539 produced the highest number of leaves at all stages of observation and in both wet seasons (Tables 3 & 4). Variety TI 468, which was the tallest had the least number of leaves at all stages in both years. The number of leaves ranged from about 11-15 at 3 WAT, 12 - 16 at 6 WAT and 15 - 18 at 9 WAT in 1995 while in 1996 it ranged from 8 to 9 at 3 WAT, 16 - 19 at 6 WAT and 15 - 20 at 9 WAT.

Inter-row spacing had no significant effect on the number of leaves produced by the four tomato varieties except at a 3 WAT in the 1996 trial. At the 3 WAT, spacing at inter-row of 60 and 75cm resulted in similar but more leaves per plant compared to the closer inter-row spacing of 45cm.

Intra-row spacing also affected the number of leaves significantly at 3 WAT in 1996 as well as at 9 WAT in both 1995 and 1996. In all these cases, the intra-row spacing at 45cm produced plants with the highest number of leaves when compared with either the closest (30cm) or widest (60cm) intra-row spacings. The difference, however, between the 45cm and 30cm at 3 WAT in the 1996 trial was not significant.

Significant interaction was recorded between inter- and intra-row spacings at 3 WAT in 1996 (Table 5). Increasing the intra-row spacing from 30cm to 45 and 60cm significantly reduced the number of leaves per plant when the inter-row spacing was maintained at 75cm. But with the inter-row spacing at 45 or 60cm a change of intra-row spacing had no significant influence on

leaf number. At any given intra-row spacing, increasing the inter-row spacing from 45 or 60cm to 75 reduced leaf number when the intra-row spacing was wider (45 and 60cm). But at the closest intra-row spacing of 30cm, the change in inter-row spacing had no significant effect on leaf number.

The interaction between intra-row spacing and variety was significant at 9 WAT in the 1996 trial (Table 6). At an intra-row spacing of 60cm, all varieties tested had similar leaf number. But the varieties exhibited significantly varying leaf number at the closer intra-row spacing. At the closer spacing, variety TI 539 exhibited a significantly higher number of leaves than other varieties. TI 106 also had significantly more leaves than TI 182 and TI 468 which registered the least number of leaves per plant at the 45 and 30cm intra-row spacing.

Table 3: Effect of inter- and intra-row spacings on number of leaves of four tomato varieties duringthe 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	14.4a	15.2a	17.6a
TI 182	11.8b	12.4b	15.0b
TI 468	11.4b	12.0b	14.7b
TI 539	15.0a	15.6a	17.3a
SE ±	0.67	1.69	1.73
Inter-row spacings (cm)			
45	11.8	13.3	15.9
60	12.0	14.6	15.4
75	13.3	14.3	17.1
SE ±	0.54	1.59	1.66
Intra-row spacings (cm)			
30	11.5	13.7	15.1b
45	12.1	14.8	17.6a
60	13.0	14.6	15.7b
SE ±	0.54	1.59	1.66
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 4: Effect of inter- and intra-row spacings on number of leaves of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	9.02a	18.5b	19.6a
TI 182	8.28b	17.6b	16.2b
TI 468	7.67c	15.8c	15.4b
TI 539	8.34b	19.1a	19.4a
SE ±	0.20	1.50	1.72
Inter-row spacings (cm)			
45	7.76b	17.7	16.3
60	8.51a	17.9	16.0
75	8.55a	18.4	18.3
SE ±	0.13	1.41	1.64
Intra-row spacings (cm)			
30	8.29a	18.5	16.2b
45	8.55a	17.4	18.8a
60	7.99b	18.2	16.5b
SE ±	0.13	1.41	1.64
Interactions			
I x i	*	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	*
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance.
NS = Not significant.I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 5: Interaction of inter- x intra-row spacing on number of leaves per plant of tomato at 3WAT during the 1996 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	8.91a	8.39a	8.36a
60	8.31a	8.76a	8.46a
75	8.50a	7.64b	7.15b
SE ±	0.23		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 6: Interaction of intra-row spacing x variety on number of leaves per plant of tomato at 9 WAT during the 1996 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	18.7b	18.0b	16.0bc
TI 182	14.9c	14.0bc	14.6c
TI 468	14.9c	14.3c	16.0bc
TI 539	24.4a	24.3a	16.1bc
SE ±	1.20		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.1.3 Leaf area index (LAI).

The effects of inter and intra-row spacings on the leaf area index (LAI) of four tomato varieties as estimated at 3, 6 and 9 WAT are presented in Tables 7 and 8 for the 1995 and 1996 trials, respectively. In both 1995 and 1996 and at all the sampling periods, variety TI 539 had significantly higher LAI than TI 106 followed by TI 182 and TI 468 in that order.

Inter-row spacing significantly affected the LAI. There was a successive reduction in LAI as the intra-row spacing widened from 45cm to 75cm. Similarly, the LAI was significnatly reduced with each successive increase in the intra-row spacing from 30cm to 60cm.

There was a significant interaction recorded between variety and intra-row spacing at 3 and 9 WAT in 1995 experiment only (Tables 9 and 10, respectively). At 3 WAT (Table 9) while the LAI for TI 106, TI 182 and TI 539 significantly declined as the intra-row spacing widened beyond 30cm there was no such response for TI 468. That is, all other varieties except TI 468 responded significantly to the increase in intra-row spacing.

The response of LAI to changes in intra-row spacing also varied significantly with varieties at 9 WAT (Table 10). As observed at 3WAT, the variety TI 468 did not respond significantly to change in intra-row spacing. LAI for TI 106 and 182 planted at 45cm and 60cm spacing were statistically similar but lower than the value at 30cm. Variety TI 539 showed similar and higher LAI at 30 and 45cm spacing compared with the value at 60cm spacing.

Table 7 Effect of inter- and intra-row spacings on leaf area index of four tomato varieties during the 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	0.90b	2.48b	4.60b
TI 182	0.57c	2.00c	3.22c
TI 468	0.32d	1.51d	2.09d
TI 539	1.02a	4.92a	7.31a
SE ±	0.04	0.16	0.23
Inter-row spacings (cm)			
45	0.81a	2.94a	4.96a
60	0.65b	2.60b	4.08b
75	0.60c	2.24c	3.87c
SE ±	0.04	0.11	0.20
Intra-row spacings (cm)			
30	0.90a	3.01a	5.46a
45	0.67b	2.62b	4.33b
60	0.55c	2.23c	3.12c
SE ±	0.04	0.11	0.20
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	*	NS	*
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% levels of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 8: Effect of inter- and intra-row spacings on leaf area index of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	0.82b	2.71b	5.21b
TI 182	0.43c	2.12c	3.29c
TI 468	0.29d	1.53d	2.11d
TI 539	0.98a	5.70a	8.03a
SE ±	0.04	0.18	0.26
Inter-row spacings (cm)			
45	0.77a	3.44a	5.34a
60	0.63b	2.82b	4.27b
75	0.53c	2.32c	3.61c
SE ±	0.03	0.14	0.21
Intra-row spacings (cm)			
30	0.82a	3.58a	5.74a
45	0.65b	2.79b	4.51b
60	0.51c	2.30c	3.42c
SE ±	0.03	0.14	0.21
Interactions			
I x i	**NS**	**NS**	NS
I x V	**NS**	**NS**	NS
i x V	**NS**	**NS**	NS
I x i x V	**NS**	**NS**	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 9: Interaction of intra-row spacing x variety on leaf area index of tomato at 3 WAT during the 1995 wet season at Samaru.

	Intra-row spacing (cm)		
Treatments	30	45	60
Variety			
TI 106	1.29a	0.78cd	0.64de
TI 182	0.79cd	0.53ef	0.39f
TI 468	0.43efg	0.31g	0.24g
TI 539	1.29a	0.78cd	0.64de
SE ±	0.08		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 10: Interaction of intra-row spacing x variety on leaf area index of tomato at 9 WAT during the 1995 wet season at Samaru.

	Intra-row spacing (cm)		
Treatments	30	45	60
Variety			
TI 106	6.55b	4.15de	3.08ef
TI 182	4.28cd	3.01f	2.36f
TI 468	2.76fg	1.78g	1.73g
TI 539	8.25a	8.36a	5.31c
SE ±	0.39		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.1.4 Total dry matter (TDM).

Tables 11 and 12 show the effect of inter- and intra-row spacings on the total dry matter (TDM) of four tomato varieties at Samaru in 1995 and 1996, respectively. In both 1995 and 1996 the four varieties differ significantly in their total dry matter except at 9WAT in 1996. In both years variety TI 468 produced significantly higher (TDM) compared with the three other varieties which were at par.

In both 1995 and 1996, inter-row spacing affected TDM significantly only at 6 WAT where the 75cm spacing registered higher TDM than the at 60 and 45cm spacings whose TDM were at par.

Like the inter-row spacing, the intra-row spacing also affected the TDM only at 6 WAT in both 1995 and 1996. Tomatoes planted at 60cm intra-row spacing had significantly more TDM than at the closer 45 and 30cm spacings which were at par with each other.

None of the interactions was significant in both wet seasons.

Table 11: Effect of inter- and intra-row spacings on total dry matter (g) of four tomato varieties during the 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	1.26b	13.5b	26.5b
TI 182	1.18b	13.3b	24.1b
TI 468	1.42a	14.6a	29.6a
TI 539	1.17b	13.2b	26.3b
SE ±	0.06	0.15	1.02
Inter-row spacings (cm)			
45	0.30	13.2b	24.9
60	1.37	13.6b	25.7
75	1.44	14.4a	26.9
SE ±	0.06	0.13	1.24
Intra-row spacings (cm)			
30	1.29	13.2b	24.5
45	1.38	13.6b	25.8
60	1.46	14.7a	27.2
SE ±	0.06	0.13	1.24
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 12: Effect of inter- and intra-row spacings on total dry matter (g) of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	1.44b	17.1b	30.8
TI 182	1.51b	17.0b	31.2
TI 468	2.09a	21.5a	34.0
TI 539	1.27b	17.3b	30.6
SE ±	0.09	0.23	1.20
Inter-row spacings (cm)			
45	1.45	14.1b	30.1
60	1.58	14.7b	31.6
75	1.62	18.9a	33.4
SE ±	0.10	0.20	1.29
Intra-row spacings (cm)			
30	1.40	14.9b	29.7
45	1.56	15.4b	32.8
60	1.64	17.8a	33.2
SE ±	0.10	0.20	1.29
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.1.5 Relative growth rate (RGR).

RGR determined at 6 and 9 WAT as affected by the inter and intra-row spacings of the four tomato varieties are shown in Tables 13 and 14, for the 1995 and 1996 wet season trials, respectively. At 6 WAT during both wet seasons TI 468 had a significnatly higher RGR than the other three varieties which were at par with each other. At 9 WAT in 1995, RGR was also highest in TI 468 followed by TI 539 which in turn had significantly higher RGR than TI 106 and 182 which were similar. At 9 WAT in 1996, TI 468 also had significantly higher RGR than TI 539 followed by TI 106 and TI 182 in that order.

In both 1995 and 1996, inter-row spacings affected RGR significantly at both the sampling periods with 45 and 60cm having significantly higher RGR than 75cm. Like the inter-row spacings, the intra-row spacings also affected the tomato RGR significantly at both the sampling periods in both wet seasons, with 30 and 45cm having significantly higher RGR than the 60cm intra-row spacing. None of the interactions was significant in both wet seasons.

Table 13: Effect of inter- and intra-row spacings on relative growth rate (g/g/wk) of four tomato varieties during the 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	0.77b	0.24c
TI 182	0.72b	0.22c
TI 468	0.94a	0.34a
TI 539	0.74b	0.29b
SE ±	0.02	0.005
Inter-row spacings (cm)		
45	0.84a	0.29a
60	0.81a	0.28a
75	0.73b	0.22b
SE ±	0.02	0.005
Intra-row spacings (cm)		
30	0.86a	0.29a
45	0.82a	0.28a
60	0.74b	0.23b
SE ±	0.02	0.005
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 14: Effect of inter- and intra-row spacings on relative growth rate (g/g/wk) of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	0.71b	0.29c
TI 182	0.68b	0.26d
TI 468	0.90a	0.40a
TI 539	0.68b	0.34b
SE ±	0.03	0.006
Inter-row spacings (cm)		
45	0.78a	0.36a
60	0.76a	0.35a
75	0.68b	0.30b
SE ±	0.02	0.005
Intra-row spacings (cm)		
30	0.81a	0.36a
45	0.76a	0.36a
60	0.69b	0.31b
SE ±	0.02	0.005
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.

V = Varieties.

4.1.6 Net assimilation rate (NAR).

In both 1995 and 1996, the four tomato varieties differ significantly in their net assimilation rate (NAR) at both 6 and 9 WAT (Tables 15 and 16, respectively). In 1995, at both sampling periods, TI 106 had significantly higher NAR compared with the other varieties. This was followed by TI 182 and 468 which were at par with each other and also significantly better than TI 539. In 1996, at 6 WAT TI 106 and 182 recorded similar and significantly higher NAR than TI 468 and 539 which also had similar NAR. In 1996, at 9 WAT, TI 106, 182 and 539 had similar and significantly higher NAR than TI 468.

The inter-row spacings also significantly affected the NAR of the tomato varieties in both years and at both sampling periods, with 45cm having significantly higher NAR than 60cm followed by 75cm inter-row spacing in that order.

The intra-row spacings also significantly affected the NAR of the four tomato varieties tested in both years and also at both sampling periods, with 30cm intra-row spacing having significantly higher NAR than 45cm which also had significantly higher NAR than 60cm.

None of the interactions was observed to be significant in both wet seasons.

Table 15: Effect of inter- and intra-row spacings on net assimilation rate (g/cm^2/wk) of four tomato varieties during the 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	2.82a	0.52a
TI 182	2.46b	0.44b
TI 468	2.40b	0.43b
TI 539	2.18c	0.34c
SE ±	0.05	0.02
Inter-row spacings (cm)		
45	2.57a	0.47a
60	2.21b	0.43b
75	2.10c	0.38c
SE ±	0.03	0.01
Intra-row spacings (cm)		
30	2.60a	0.47a
45	2.24b	0.42b
60	2.03c	0.36c
SE ±	0.03	0.01
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 16: Effect of inter- and intra-row spacings on net assimilation rate ($g/cm^2/wk$) of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	2.73a	0.41a
TI 182	2.69a	0.44a
TI 468	2.44b	0.37b
TI 539	2.41b	0.42a
SE ±	0.05	0.02
Inter-row spacings (cm)		
45	2.65a	0.45a
60	2.51b	0.41b
75	2.40c	0.37c
SE ±	0.03	0.01
Intra-row spacings (cm)		
30	2.64a	0.46a
45	2.53b	0.42b
60	2.43c	0.38c
SE ±	0.03	0.01
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.1.7 Number of flowers.

Tables 17 and 18 show the number of flowers as affected by the treatments in 1995 and 1996, respectively. At 5 WAT in 1995 and 6 WAT in 1996 the number of flowers produced by varieties TI 106 and TI 539 were at par and significantly higher than that produced by varieties TI 182 and TI 468 which were also at par. However, no significant difference in number of flowers among the varieties were observed at 6 and 7 WAT in 1995, and at 5 and 7 WAT in 1996.

Inter-row spacing did not significantly affect the number ;of flowers produced by the tomato varieties in 1995 at all the sampling period while it did at 5 and 6 WAT in 1996. At 5 WAT of the 1996 trial, planting at 45cm inter-row spacing resulted in the highest number of flowers than 60 and 75cm inter-row spacings. At 6 WAT however, the 60cm inter-row spacing, had plants with more flowers and was at par with the 75cm spacing but significantly higher than the 45cm spacing.

In 1995, the effect of intra-row spacing was significant only at 7 WAT when the number of flowers produced per plant at 60 and 45cm spacing was at par and significantly more than at 30cm intra-row spacing. In 1996 significant differences were observed between the various intra-row spacings at all stages of observation. At 6 and 7 WAT the 60cm intra-row spacing was at par with the 45cm spacing and significantly higher than the 30cm intra-row spacing. But at 5 WAT, the 45cm intra-row spacing resulted in plants with more flowers per plant than the

60 or 30cm spacings, which were at par.

Significant interaction was recorded between variety and intra-row spacing at 6 WAT in 1996 (Table 19). Only varieties TI 106 and TI 468 responded significantly when the intra-row spacing was reduced from 60cm to 45cm. Thereafter, the differences between 45cm and 30cm spacing was not significant. For variety TI 539, there was no significant difference in flower number when spacing was reduced from 60cm to 45cm but a further reduction to 30cm significantly reduced flowering. Variety TI 182, on the other hand, was unaffected by change in intra-row spacing.

Table 17: Effect of inter- and intra-row spacings on number of flowers of four tomato varieties during the 1995 wet season at Samaru.

Treatments	Weeks After Transplanting 5	6	7
Varieties			
TI 106	13.9a	17.4	21.6
TI 182	10.4b	14.3	17.5
TI 468	10.1b	14.8	19.0
TI 539	13.7a	17.8	20.9
SE ±	1.12	1.30	1.53
Inter-row spacings (cm)			
45	12.9	16.8	21.0
60	12.0	15.9	18.4
75	12.0	15.6	19.8
SE ±	0.93	1.03	1.20
Intra-row spacings (cm)			
30	11.6	14.7	14.9b
45	13.2	17.3	21.7a
60	11.6	16.5	22.6a
SE ±	0.93	1.03	1.20
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 18: Effect of inter- and intra-row spacings on number of flowers of four tomato varieties during the 1996 wet season at Samaru.

Treatments	Weeks After Transplanting 5	6	7
Varieties			
TI 106	14.3	19.2a	23.7
TI 182	14.0	17.7b	19.9
TI 468	14.3	17.8b	19.1
TI 539	15.0	19.3a	21.9
SE ±	0.40	0.44	1.34
Inter-row spacing (cm)			
45	15.3a	17.3b	17.9
60	13.7b	19.1a	18.4
75	14.6b	19.0a	19.8
SE ±	0.38	0.43	1.22
Intra-row spacings (cm)			
30	14.0b	17.4b	15.1b
45	15.3a	19.2a	23.2a
60	13.9b	19.8a	24.7a
SE ±	0.38	0.43	1.22
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	*	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 19: Interaction of intra-row spacing x variety on number of flowers per plant of tomato at 6 WAT during the 1996 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	17.4cd	18.2bcd	21.5a
TI 182	16.9de	17.8cd	16.6de
TI 468	14.9e	15.7e	20.0ab
TI 539	18.5bc	21.4a	21.2a
SE ±		0.77	

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.1.8 Days to 50% flowering.

There were no significant difference among the four tomato varieties in terms of the number of days each took to 50% flowering in both 1995 and 1996 (Table 20). Neither the change in inter-row or intra-row spacing significantly affected the time the four varieties took to 50% flowering in the two years of experimentation. Interactions between the various treatments were all not significant in both wet seasons.

4.1.9 Number of days to first harvest (picking).

Like the number of days to 50% flowering, the number of days to harvest was not significantly affected by the various treatments in the two wet seasons of the trial (Table 21). The interactions were also similarly not significant .

4.1.10 Fruit firmness.

Table 22 shows the effect of the various treatments on the firmness of mature fruits of the four varieties in both wet seasons of the trial. The fruit of variety TI 539 was significantly more firm than those of the three other varieties. This was followed by TI 106 which was at par with that of variety TI 182 and which were significantly more firm than that of variety TI 468 in both wet seasons.

Both inter-and intra-row spacings did not significantly affect the firmness of the fruits of the four tomato varieties. None of the interaction was observed to be significant in both years of experimentation.

Table 20: Effect of inter- and intra-row spacings on days to 50% flowering of four tomato varieties during the 1995 and 1996 wet seasons at Samaru.

Treatments	Days to 50% flowering 1995	1996
Varieties		
TI 106	42.3	43.4
TI 182	42.4	43.5
TI 468	42.5	43.7
TI 539	42.3	43.1
SE ±	0.08	0.21
Inter-row spacing (cm)		
45	42.4	43.7
60	42.3	43.3
75	42.4	43.1
SE ±	0.07	0.19
Intra-row spacings (cm)		
30	42.5	43.8
45	42.5	43.2
60	42.3	43.2
SE ±	0.07	0.19
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 21: Effect of inter- and intra-row spacings on days to first harvest of four tomato varieties during the 1995 and 1996 wet seasons at Samaru.

Treatments	Days to first harvest 1995	1996
Varieties		
TI 106	71.3	73.2
TI 182	71.8	72.5
TI 468	71.8	73.4
TI 539	69.7	71.8
SE ±	1.02	1.34
Inter-row spacings (cm)		
45	72.4	73.3
60	70.3	71.8
75	70.2	71.9
SE ±	0.98	1.11
Intra-row spacings (cm)		
30	72.9	72.9
45	70.8	72.5
60	70.0	72.3
SE ±	0.98	1.11
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter- and intra-row spacings, respectively.
V = Varieties.

Table 22: Effect of inter- and intra-row spacings on fruit firmness (^{0}0) of four tomato varieties during the 1995 and 1996 wet seasons at Samaru.

Treatments	Fruit firmness (^{0}0) 1995	1996
Varieties		
TI 106	120.0b	129.1b
TI 182	118.2b	117.1b
TI 468	77.6c	74.5c
TI 539	134.4a	148.1a
SE ±	2.99	2.92
Inter-row spacings (cm)		
45	111.0	114.7
60	117.1	119.3
75	112.6	117.4
SE ±	2.46	2.36
Intra-row spacings (cm)		
30	114.2	115.5
45	119.0	116.6
60	119.8	119.3
SE ±	2.46	2.36
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.1.11 Percent soluble solids.

The effects of the treatments on the percent soluble solids content of fruits of the four tomato varieties are shown on Table 23. The four varieties differ significantly in their percent soluble solids in both 1995 and 1996 with variety TI 468 having significantly higher soluble solids content than the other three varieties which were at par.

Inter-row spacing was observed to have no significant effect on the percent soluble solids in both 1995 and 1996 wet season trials.

It was only during the 1996 wet season that intra-row spacing significantly affected the amount of soluble solids content of fruit. Those tomato plants spaced at 30cm between stands produced fruits with significantly higher soluble solids than those at wider 45 and 60cm which were at par with each other.

The interaction effect that was significant was that between intra-row spacing and varieties in 1996 (Table 24). Although the main effect revealed that 30cm spacing produced fruits with significantly higher soluble solids than at wider spacing, this was true for only one variety TI 468. The change in intra-row spacing had no significnat effect on the other three varieties.

Table 23: Effect of inter- and intra-row spacings on percent soluble solids of four tomato varieties during the 1995 and 1996 wet season at Samaru.

Treatments	Percent soluble solids (%) 1995	1996
Varieties		
TI 106	0.65b	0.62b
TI 182	0.57b	0.63b
TI 468	1.42a	1.39a
TI 539	0.51b	0.48b
SE ±	0.09	0.07
Inter-row spacings (cm)		
45	0.81	0.86
60	0.79	0.76
75	0.77	0.72
SE ±	0.06	0.05
Intra-row spacings (cm)		
30	1.10	1.05a
45	0.71	0.65b
60	0.68	0.65b
SE ±	0.06	0.05
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	*
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 24: Interaction of intra-row spacing x variety on percent soluble solids (%) of tomato during the 1996 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	0.68cd	0.69cd	0.48d
TI 182	0.80cd	0.49d	0.42d
TI 468	1.98a	1.21b	1.20b
TI 539	0.52d	0.51d	0.43d
SE ±		0.12	

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.1.12 Average fruit weight.

In 1995, varieties TI 468 and TI 539 had statistically similar and higher fruit weight than those of varieties TI 106 and TI 182 that were also at par with each other (Table 25). In 1996, variety TI 468 also produced the heaviest fruit, significantly heavier than that of TI 539; but both varieties have significantly heavier mean fruit weight than TI 106 and TI 182 which were at par with each other.

Neither inter-row nor intra-row spacing had statistically significant effect on the fruit weight of the four tomato varieties in both 1995 and 1996.

The interaction between variety and intra-row spacing was found to be significant in both wet seasons (Tables 26 and 27, respectively). TI 539 at 60cm intra-row spacing gave the highest average fruit weight in 1995 (Table 26) In this year, varieties TI 539 and TI 182 responded significantly to the increase in spacing from 30cm to 60cm while varieties TI 106 and TI 468 were not responsive. In 1996, TI 468 at 60cm intra-row spacing gave the highest average fruit weight (Table 27). Here only the variety TI 468 responded to changes in spacing with 60cm having the higher average fruit weight than 30 and 45cm which were similar.

Table 25: Effect of inter- and intra-row spacings on average fruit weight (g) of four tomato varieties during the 1995 and 1996 wet seasons at Samaru.

Treatments	Average fruit weight (g) 1995	1996
Varieties		
TI 106	36.0b	37.9c
TI 182	36.8b	35.4c
TI 468	42.7a	52.4a
TI 539	45.7a	42.2b
SE ±	1.22	0.98
Inter-row spacings (cm)		
45	38.8	41.1
60	40.7	42.2
75	40.7	42.6
SE ±	1.08	0.90
Intra-row spacings (cm)		
30	38.4	40.9
45	40.4	42.1
60	41.4	42.9
SE ±	1.08	0.90
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	*	*
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 26: Interaction of intra-row spacing x variety on average fruit weight (g) of tomato during the 1995 wet season at Samaru.

	Intra-row spacing (cm)		
Treatments	30	45	60
Variety			
TI 106	35.9d	35.7d	37.5d
TI 182	34.7d	37.7d	45.9ab
TI 468	41.1a-d	41.1a-d	48.8a-d
TI 539	39.0b-d	39.9b-d	46.3a
SE ±	2.11		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 27: Interaction of intra-row spacing x variety on average fruit weight (g) of tomato during the 1996 wet season at Samaru.

	Intra-row spacing (cm)		
Treatments	30	45	60
Variety			
TI 106	36.1de	36.7de	40.9cd
TI 182	34.7e	35.4e	36.1de
TI 468	48.7b	49.0b	59.5a
TI 539	40.5cd	42.9c	43.3c
SE ±	1.70		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.1.13 Yield per plant.

Table 28 shows the effect of the various treatments on the average yield per plant of the tomato varieties in both wet seasons of the trial. In 1995, varieties TI 106 and 539 produced similar and significantly higher fruit yield per plant than TI 182 and 468 which had similar fruit yield per plant. In 1996, TI 106 and 539 also produced similar and significantly higher fruit yield per plant than TI 182 which, in turn also produced significantly higher fruit yield per plant than TI 468.

During both seasons, the two higher inter and intra-row spacing levels (60 and 75cm and 45 and 60cm, respectively), produced similar and significantly higher fruit yield per plant than the least inter and intra-row spacing levels of 45 and 30cm, respectively.

All interaction effects between the various treatments were not significant statistically in both wet seasons.

Table 28: Effect of inter- and intra-row spacings on yield per plant (kg) of four tomato varieties during the 1995 and 1996 wet seasons at Samaru.

Treatments	Yield per plant (kg) 1995	1996
Varieties		
TI 106	0.51a	0.85a
TI 182	0.44b	0.71b
TI 468	0.39b	0.60c
TI 539	0.50a	0.89a
SE ±	0.03	0.03
Inter-row spacings (cm)		
45	0.40b	0.63b
60	0.46a	0.81a
75	0.50a	0.85a
SE ±	0.03	0.03
Intra-row spacings (cm)		
30	0.37b	0.68b
45	0.50a	0.80a
60	0.52a	0.81a
SE ±	0.03	0.03
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.1.14 Total fruit yield.

The total fruit yield ranged between 18-28t/ha (Table 29). Variety TI 539 had the highest fruit yield in both seasons and was significantly more than those of other varieties, except TI 106 in 1995 only. Variety TI 106 and TI 182 had similar and significantly higher total fruit yield than TI 468 whcih had the least yield/ha in both wet seasons.

The 45 and 60cm inter-row spacing resulted in significantly better fruit yield than the 75cm spacing in both 1995 and 1996 wet seasons. Similarly the 30 and 45cm intra-row spacings were significantly better than the 60cm spacing in the two wet seasons.

All the interaction effects between the various treatments were significant in both wet seasons. The interaction between inter and intra-row spacing showed that in both years, at the widest inter-row spacing, the change in intra-row spacing produced no significant effect on total fruit yield (Tables 30 and 31, respectively). At 60cm inter-row spacing, the decrease in intra-row spacing from 60 cm to 45cm and 30cm gave the highest total fruit yield. At 45cm inter-row spacing, decreasing intra-row spacing from 60cm to 45cm and 30cm gave the lowest total fruit yield.

Interaction between inter-row spacing and variety in 1995 showed that varieties TI 106, TI 468 and TI 539 produced similar total fruit yield at their respective inter-row spacing levels (Table 32). TI 182 produced similar total fruit yield at 45 and

60cm which was significantly higher than that produced at 75cm. Interaction between inter-row spacing and variety in 1996 showed that TI 468 and TI 539 did not respond to any changes in their inter-row spacing levels (Table 33). Varieties TI 106 and TI 182 had higher total fruit yield at 60cm than at 45 and 75cm inter-row spacings.

Interaction between intra-row spacing and variety in 1995 showed that varieties TI 182, TI 468 and TI 539 did not respond significantly to any changes in intra-row spacing (Table 34). However, TI 106 produced similar total fruit yield at 30 and 45cm intra-row spacing which was significantly higher than that at 60cm intra-row spacings. In 1996, interaction between intra-row spacing and varieties showed that TI 468 had similar total fruit yield at all intra-row spacing levels, while varieties TI 106, TI 182 and TI 539 had similar total fruit yield at 30 and 45cm intra-row spacing which was significantly higher than that at 60cm (Table 35).

The second order of interaction between inter-row spacing, intra-row spacing and the tomato varieties showed that in both 1995 and 1996 wet seasons the highest fruit yields were recorded by 45cm x 45 x TI 539 (Table 36 and 37, respectively) and the lowest by 75cm x 30cm x TI 182 in 1995 and 75cm x 30cm x TI 468 in 1996.

Table 29: Effect of inter- and intra-row spacings on total fruit yield (t/ha) of four tomato varieties during the 1995 and 1996 wet seasons at Samaru.

Treatments	Total fruit yield (t/ha) 1995	1996
Varieties		
TI 106	25.3ab	23.5b
TI 182	23.2b	22.3b
TI 468	18.3c	17.9c
TI 539	28.2a	26.3a
SE ±	1.69	0.91
Inter-row spacings (cm)		
45	27.7a	24.4a
60	24.8a	22.4a
75	20.1b	20.0b
SE ±	1.57	0.80
Intra-row spacings (cm)		
30	27.2a	24.8a
45	25.2a	22.6a
60	20.2b	20.1b
SE ±	1.57	0.80
Interactions		
I x i	**	**
I x V	**	**
i x V	**	**
I x i x V	**	**

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

** = Significant at 1% level of significance
NS = Not significant. I and i = inter- and intra-row spacings, respectively.
V = Varieties.

Table 30: Interaction of inter x intra-row spacing on total fruit yield (t/ha) of tomato during the 1995 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	23.2bc	22.4bc	31.4a
60	31.6a	31.8a	21.0c
75	20.2c	23.9bc	19.4c
SE ±	2.07		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 31: Interaction of inter x intra-row spacing on total fruit yield (t/ha) of tomato during the 1996 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	19.1d	19.9cd	26.9a
60	24.9ab	27.1a	21.3cd
75	19.7c	22.5bc	20.8cd
SE ±	1.10		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 32: Interaction of inter-row spacing x variety on total fruit yield of tomato during the 1995 wet season at Samaru.

Treatments	Inter-row spacing (cm) 45	60	75
Variety			
TI 106	26.3ab	24.2abc	25.4ab
TI 182	27.3ab	21.0bc	15.3d
TI 468	18.7cd	24.3a-c	24.5a-c
TI 539	30.8a	28.6a	25.1ab
SE ±	2.51		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 33: Interaction of inter-row spacing x variety on total fruit yield (t/ha) of tomato during the 1996 wet season at Samaru.

Treatments	Inter-row spacing (cm) 45	60	75
Variety			
TI 106	22.9bc	24.8ab	22.8bc
TI 182	21.7bc	25.0ab	20.3cd
TI 468	15.7d	18.7cd	19.4cd
TI 539	29.2a	25.4ab	25.3ab
SE ±	1.57		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 34: Interaction of intra-row spacing x variety on total fruit yield (t/ha) of tomato during the 1995 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	28.3a	26.1a	21.0bc
TI 182	25.3ab	20.2bc	19.2bc
TI 468	15.6c	18.2c	19.4bc
TI 539	29.7a	29.2a	25.6ab
SE ±	2.51		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 35: Interaction of intra-row spacing x variety on total fruit yield (t/ha) of tomato during the 1996 wet season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	22.2bc	24.6b	19.3cd
TI 182	22.8b	24.6b	19.7cd
TI 468	16.4d	18.0d	19.3cd
TI 539	29.3a	25.2a	24.5b
SE ±	1.57		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 36: Interaction of variety x inter-row x intra-row spacings on total fruit yield (t/ha) of tomato during the 1995 wet season at Samaru.

Treatments		Variety			
		TI 106	TI 182	TI 468	TI 539
Inter-row spacing (cm)	Intra-row spacing(cm)				
45	30	27.7a	26.7ab	13.4e	35.7a
	45	34.7a	37.6a	25.0abc	37.8a
	60	16.6cde	17.8cde	29.6ab	35.2a
60					
	30	18.2cde	24.5abc	17.4cde	29.2ab
	45	28.5ab	20.9cde	24.8abc	28.9ab
	60	28.4ab	20.6cde	31.2ab	27.8ab
75					
	30	31.2ab	13.2e	13.7e	26.4ab
	45	25.5abc	18.7cde	21.9bcde	25.8cde
	60	19.3cde	13.8e	20.4cde	23.3bcd
SE ±	3.82				

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 37: Interaction of variety x inter-row x intra-row spacings on total fruit yield (t/ha) of tomato during the 1996 wet season at Samaru.

Treatments		Variety			
		TI 106	TI 182	TI 468	TI 539
Inter-row spacing (cm)	Intra-row spacing(cm)				
45	30	27.1abc	29.2abc	15.8f	30.5a
	45	23.5bcd	26.2abc	18.7ef	31.4a
	60	23.8bcd	19.6def	21.6de	25.9abcd
60	30	25.0abcd	23.6bcde	21.3de	28.7ab
	45	23.6cd	19.9def	20.7de	22.1cde
	60	20.1de	21.1cde	16.2e	22.4cde
75	30	26.1abcd	20.1def	14.6f	28.8ab
	45	19.8def	22.5cde	14.9f	25.1abcd
	60	22.6cde	18.3ef	17.4ef	22.0cde
SE ±			2.21		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.1.15 Correlation and path coefficient analysis 1995 wet season.

Correlation studies between total fruit yield of tomato and other plant parameters during the 1995 season are presented in Table 38. There was a very strong positive correlation at 1% level of significance between total fruit yield and yield per plant, average fruit weight, number of flowers per plant (7 WAT) and leaf area index (9 WAT). Total fruit yield was also positively correlated to fruit firmness, NAR and plant height (9 WAT) at 5% level of significance. But a negative and highly significant correlation was observed between total fruit yield and days to 50% flowering at 1% level of significance. Considering correlation between the major yield components it was observed that yield per plant was positively and highly correlated (1%) to average fruit weight and to number of flowers per plant, (7 WAT). Average fruit weight was also positively and highly significantly correlated to number of flowers/plant (7 WAT).

The direct and indirect effects (contribution) of vegetative growth characters on total fruit yield are presented in Table 39 and the path coefficient diagram between total fruit yield and the vegetative characters in presented in Figure 1. They revealed that plant height contributed directly 16.2% to total fruit yield. Indirectly, plant height contributed via number of leaves and total dry matter 0.1% and 0%, respectively. Thus, total contribution by plant height to total fruit yield was 16.3%, When the contribution of number of leaves/plant to total

fruit yield was examined, the direct effect was found to be 4.30% and the indirect effects via plant height and total dry matter were 0.5% and -0.4%, respectively. Thus the total contribution (effect) of number of leaves/plant (direct and indirect) to total fruit yield was found to be 4.4%. When the total dry matter was investigated for its contribution to the total fruit yield, the direct effect was found to be negative and to the tune of -2.4% while the indirect effects via plant height and number of leaves/plant were 0.4% and 0.6%, respectively. Thus, the total contribution of total dry matter to total fruit yield was found to be -1.40%.

The direct and indirect contribution of yield characters on total fruit yield is presented in Table 40 and the path coefficient diagram between total fruit yield and the yield characters is prevented in Figure 2. The analyses revealed that number of flowers/plant directly contributed 27.4% to total fruit yields, and indirectly, via average fruit weight and yield/plant contributed 11.6% and 43.3%, respecitively. Thus the total contribution by number of flowers/plant to total fruit yield was 82.3%. When the contribution of average fruit weight to total fruit yield was examined the direct effect was found to be 18.4% and the indirect effects via number of flowers and yield/plant were 17.3% and 39.2% respectively. Thus, the total contribution by average fruit weight to total fruit yield was found to be 74.9%. When the yield/plant was investigated for its contribution to the total fruit yield, the direct effect was

observed to be 55.1% while the indirect effects via number of flowers and average fruit weight were 21.5% and 13.1%, *respectively. Thus the total contribution by yield/plant to* total fruit yield was 89.7%.

Table 38: Matrix of correlation coefficient between tomato fruit yield (t/ha) and various other plant parameters during the 1995 wet season at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.897**	1.000										
3	0.749**	0.711**	1.000									
4	0.823**	0.784**	0.633**	1.000								
5	0.184*	0.312**	0.241**	0.155*	1.000							
6	-0.082NS	-0.218**	-0.324**	-0.104NS	-0.257**	1.000						
7	-0.219**	-0.221**	-0.158*	-0.227**	-0.186*	-0.248**	1.000					
8	0.163*	0.024NS	0.013NS	-0.136NS	-0.231**	0.127NS	-0.179*	1.000				
9	0.463**	0.201*	0.020NS	0.157*	0.173*	-0.091NS	-0.104NS	-0.242**	1.000			
10	-0.014NS	-0.027NS	0.124NS	0.022NS	0.031NS	0.029NS	-0.138NS	0.054NS	0.038NS	1.000		
11	0.044NS	0.510**	0.004NS	0.460**	0.184*	0.199*	-0.017NS	0.011NS	0.595**	0.148NS	1.000	
12	0.162*	0.203**	0.061NS	0.018NS	0.124NS	0.045NS	-0.164*	0.157*	0.057NS	0.019NS	0.030NS	1.000

1. Total fruit yield (t/ha) 2. Yield per plant (kg) 3. Average fruit weight (g) 4. Number of flowers/plant (7WAT)

5. Fruit firmness (^{o}0) 6. Percent soluble solids (%) 7. Days to 50% flowering 8. NAR (g/cm^2/wk) (6WAT) 9. LAI (9WAT)

10. Total dry matter (g) (9WAT) 11. Number of leaves/plant (9WAT) 12. Plant height (cm) (9WAT).

Table 39: The direct and indirect contributions of different growth characters on yield (t/ha) in 1995 wet season at Samaru.

Yield attributes	Effect through			
	Plant height (cm)	Number of leaves	Total dry matter (g)	Correlation with yield.
Plant height (cm)	0.162a	0.001	0.000	0.163
Number of leaves	0.005	0.043	-0.004	0.044
Total dry matter (g)	0.004	0.006	-0.024	-0.014

(a) Direct effect underlined

Table 40: The direct and indirect contributions of different yield components on yield (t/ha)in 1995 wet seasons at Samaru.

Yield attributes	Effect through			
	Number of flowers	Average fruit weight (g)	Yield per plant(kg)	Total correlation with yield
Number of flowers	0.274a	0.116	0.433	0.823
Average fruit weight (g)	0.173	0.184	0.392	0.749
Yield per plant (kg)	0.215	0.131	0.551	0.897

(a) Direct effect underlined

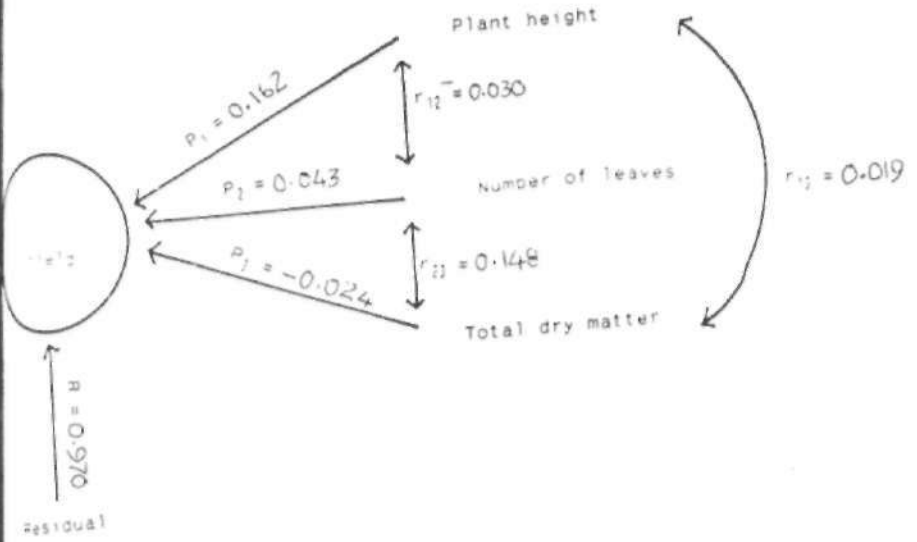


Fig. 1 Path diagram showing interrelations of total furit yield (t/ha) and some growth characters in 1984 wet season at Samaru

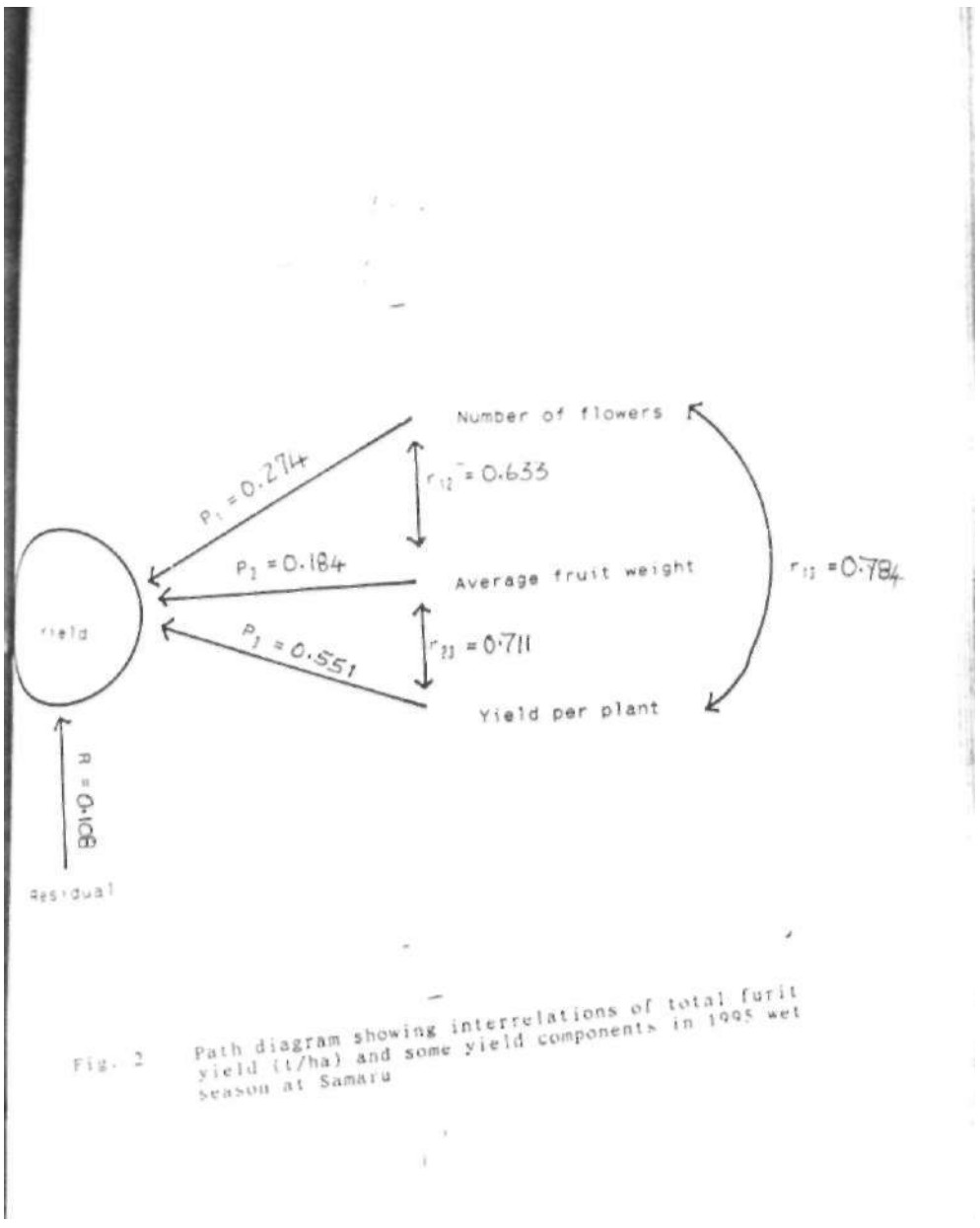


Fig. 2 Path diagram showing interrelations of total fruit yield (t/ha) and some yield components in 1995 wet season at Samaru

The percentage contributions of individual growth characters as well as the combined contributions of the characters to total fruit yield are presented in Table 41. Plant height made the highest individual contribution of 2.62% followed by number of leaves/plant (0.19%) and total dry matter had the least (0.06%). The highest combined contribution was made by plant height and number of leaves (0.04%) followed by plant height and total dry matter (-0.01%) and number of leaves and total dry matter (-0.03%). The unaccounted residual effect was 97.13%.

The percentage contributions of individual yield characters as well as the combined contributions of the characters to total fruit yield are presented in Table 42. Yield/plant made the highest individual contribution of 30.4% followed by number of flower/plant (7.52%) and average fruit weight (3.39%). The highest combined contribution was made by number of flowers and yield/plant (23.7%) followed by average fruit weight and yield/plant (14.4%) and , lastly, number of flowers and average fruit weight (6.39%). A residual effect of 14.2% was unaccounted for in the analysis.

Table 41: The percentage contributions of different growth characters to total fruit yield (t/ha) in 1995 wet season at Samaru.

Yield attributes	Percent contribution
Individual contributions	
Plant height (cm)	2.62
Number of leaves	0.19
Total dry matter (g)	0.06
Combined contributions	
Plant height and number of leaves	0.04
Plant height and total dry matter	-0.01
Number of leaves and total dry matter	-0.03
Residual	97.13
Total	100.0%

Table 42: The percentage contributions of different yield components to total fruit yield (t/ha) in 1995 wet season at Samaru.

Yield attributes	Percent contribution
Individual contributions	
Number of flowers	7.52
Average fruit weight (g)	3.39
Yield per plant (kg)	30.4
Combinal contributions	
Number of flowers and Average fruit weight	6.39
Number of flowers and yield per plant	23.7
Average fruit weight and yield per plant	14.4
Residual	14.2
Total	100.0%

4.1.16 Correlation and path coefficient analysis, 1996 wet season.

Correlation studies between total fruit yield of tomato and other plant parameters during the 1996 wet season are presented in Table 43. There was a very strong positive correlation at 1% level of significance between total fruit yield and yield per plant, average fruit weight, number of flowers per plant (7 WAT), fruit firmness, leaf area index (9WAT) and number of leaves/plant (9 WAT). Total fruit yield was also positively correlated to plant height and NAR at 5% level of significance. But a negative and highly significant correlation was observed between total fruit yield and days to 50% flowering at 1% level of significance. Considering correlation between the major yield components, it was observed that yield per plant was positively and highly significantly correlated to average fruit weight and number of flowers per plant (7 WAT). Average fruit weight was also positively and highly significantly correlated to number of flowers per plant (7 WAT).

The direct and indirect contributions of vegetative growth characters on total fruit yield are presented in Table 44 and the path coefficient diagram between total fruit yield and the vegetative growth characters is presented in Figure 3. They revealed that plant height contributed directly 20% to total fruit yield and indirectly, via number of leaves and total dry matter 0.2% and 0.1%, respectively. Thus, total contribution by plant height to total fruit yield was 20.3%. When the

contribution of number of leaves/plant to total fruit yield was examined, the direct effect was found to be 5.2% and the indirect effects, via plant height and total dry matter were 0.6% and -0.6%, respectively. Thus, the total contribution of number of leaves per plant to total fruit yield was found to be 5.2%. When the total dry matter was investigated for its contribution to total fruit yield, the direct effect was found to be -3.6% and the indirect affect via plant height and number of leaves were 0.5% and 0.8%, respectively. Thus, the total contribution of total dry matter to total fruit yield was -2.3%.

The direct and indirect contributions of yield characters on total fruit yield of tomato is presented in Table 45 and the Path Coefficient diagram between total fruit yield and the yield characters is presented in Figure 4. The analyses revealed that number of flowers/plant directly contributed 13.9% to total fruit yield, and indirectly, via average fruit weight and yield/plant contributed 10.2% and 51.6%, respectively. Thus, the total contribution by number of flowers/plant to total fruit yield was 75.7%. When the contribution of average fruit weight to total fruit yield was examined, the direct effect was found to be 16.3% and the indirect effects via number of flowers/ plant and yield/plant were 8.7% and 46.1%, respectively. Thus the total contribution by average fruit weight to total fruit yield was found to be 71.1%. When the yield/plant was investigated for its contribution to total fruit yield, the direct effect was observed to be 66% while the indirect effects, via number of flowers/plant

and average fruit weight were 10.9% and 11.3%, respectively. Thus, the total contribution by yield/plant to total fruit yield was 88.2%.

Table 43: Matrix of correlation coefficient between tomato fruit yield (t/ha) and various other plant parameters during the 1996 wet season at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.882**	1.000										
3	0.711**	0.698**	1.000									
4	0.757**	0.781**	0.627**	1.000								
5	0.255**	0.454**	0.382**	0.168*	1.000							
6	-0.075NS	-0.340**	-0.326**	-0.114NS	-0.434**	1.000						
7	-0.228**	-0.214**	-0.236**	-0.168*	-0.314**	-0.321**	1.000					
8	0.159*	0.018NS	0.019NS	-0.154NS	-0.413**	0.137NS	-0.236**	1.000				
9	0.284**	0.131NS	0.042NS	0.246**	0.241**	-0.088NS	-0.112NS	-0.324**	1.000			
10	-0.023NS	-0.184*	0.116NS	0.031NS	0.057NS	0.029NS	-0.142NS	0.072NS	0.052NS	1.000		
11	0.252**	0.120NS	0.099NS	0.460**	0.191*	-0.175*	-0.212*	0.021NS	0.241**	0.154NS	1.000	
12	0.201*	0.013NS	0.032NS	0.028NS	0.027NS	0.067NS	-0.248**	0.176*	-0.172*	0.027NS	0.032NS	1.000

1. Total fruit yield (t/ha) 2. Yield per plant (kg) 3. Average fruit weight (g) 4. Number of flowers/plant (7WAT)
5. Fruit firmness (^{0}0) 6. Percent soluble solids (%) 7. Days to 50% flowering 8. NAR (g/cm^2/wk) (6WAT) 9. LAI (9WAT)
10. Total dry matter (g) (9WAT) 11. Number of leaves/plant (9WAT) 12. Plant height (cm) (9WAT).

Table 44: The direct and indirect contributions of different growth characters on yield (t/ha) in 1996 wet seasons at Samaru.

Yield attributes	Effect through			
	Plant height (cm)	Number of leaves	Total dry matter	Total correlation with yield (g)
Plant height (cm)	0.200a	0.002	0.001	0.203
Number of leaves	0.006	0.052	-0.006	0.052
Total dry matter (g)	0.005	0.008	-0.036	-0.023

(a) Direct effect underlined

Table 45: The direct and indirect contributions of different yield components on yield (t/ha) in 1996 wet seasons at Samaru.

Yield attributes	Effect through			
	Number of flower	Average fruit weight (g)	Yield per Plant (kg)	Total correlation with yield
Number of flowers	0.139a	0.102	0.516	0.757
Average fruit weight (g)	0.087	0.163	0.461	0.711
Yield per plant (kg)	0.109	0.113	0.660	0.882

(a) Direct effect underlined

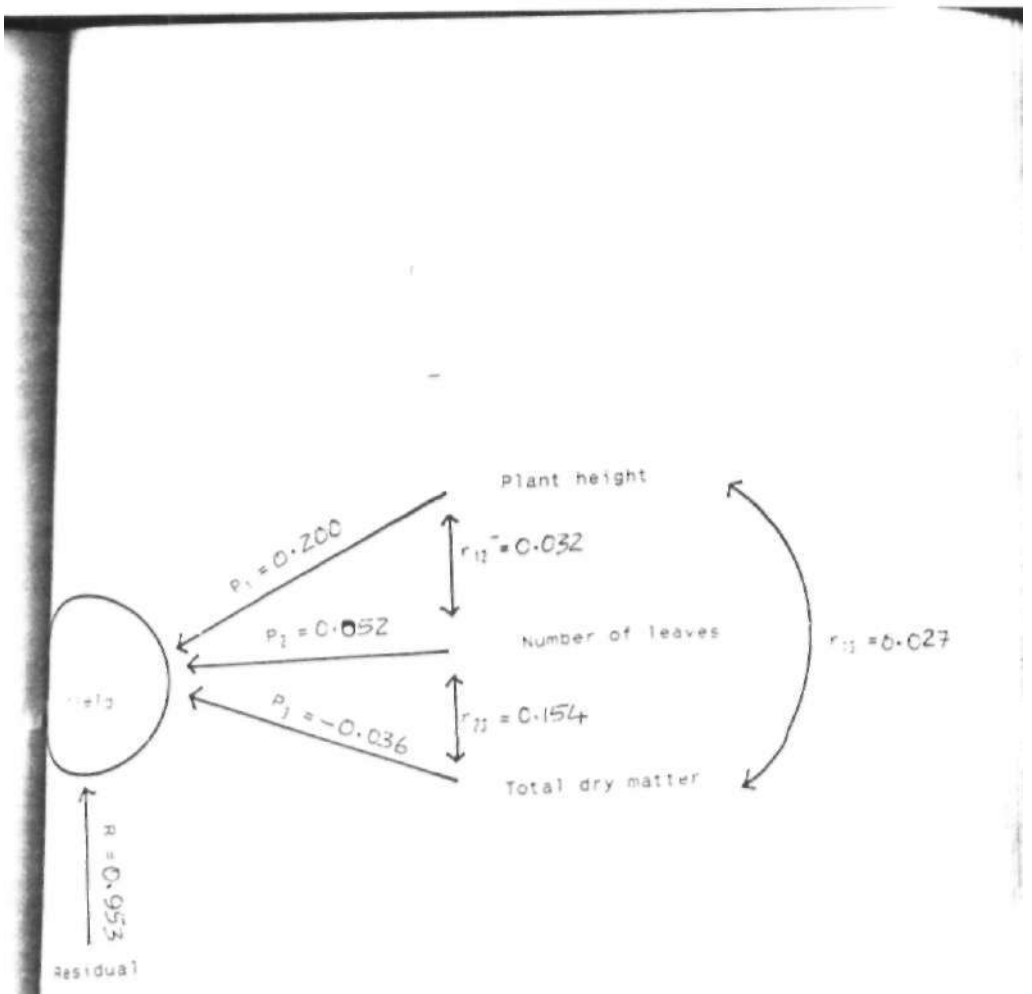


Fig. 3 Path diagram showing interrelations of total fruit yield (t/ha) and some growth characters in Dec-act season at Samaru

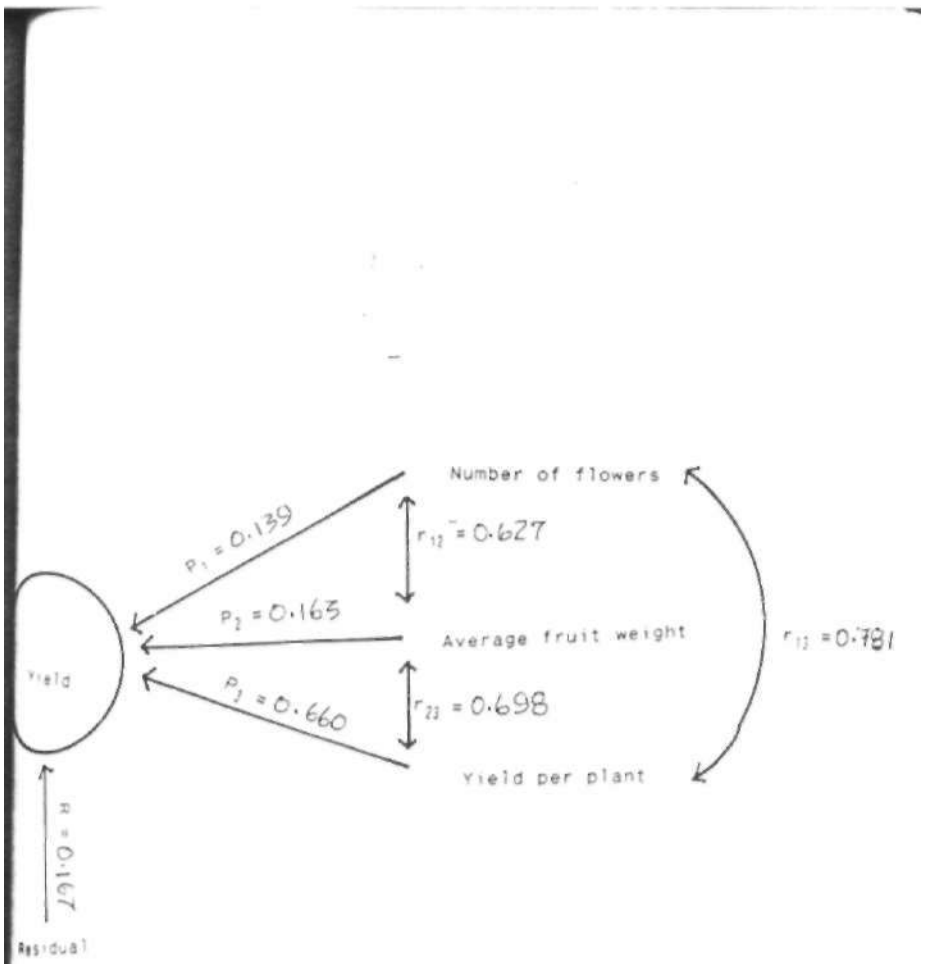


Fig. 4 Path diagram showing interrelations of total furit yield (t/ha) and some yield components in 1996 wet season at Samaru

The percentage contributions of individual growth characters as well as their combined contributions to total fruit yield are presented in Table 46. Plant height made the highest individual contribution of 4.0% followed by number of leaves/ plant (0.27%) and total dry matter had the least (0.13%). The highest combined contribution was made by plant height and number of leaves/plant (0.07%) followed by plant height and total dry matter (-0.04%) and number of leaves and total dry matter (-0.06). The unaccounted residual effect was 95.63%.

The percentage contributions of individual yield characters as well as their combined contributions to total fruit yield of tomato are presented in Table 47. Yield/plant made the highest individual contribution of 43.6% followed by average fruit weight, (2.65%) and number of flowers/plant (1.93%). The highest combined contribution was made by average fruit weight and yield/plant (15.0%) followed by number of flowers/plant and yield/plant (14.3%) and, lastly number of flowers/plant and average fruit weight (2.82%). A residual effect of 19.7% was unaccounted for in the analysis.

4.1.17 Polynomial response of total fruit yield to inter and intra-row spacing levels, 1995 and 1996 wet seasons.

Tables 48 and 49 showed the deviations between observed and expected total fruit yields of tomato using the regression equations developed for both 1995 and 1996 wet seasons, respectively. It was observed that all deviations between observed and expected for both linear and quadratic regressions in both inter and intra-row spacings for both wet seasons were not significant.

Table 46: The percentage contributions of different growth characters to total fruit yield (t/ha) in 1996 wet season at Samaru.

Yield attributes	Percent contribution
Individual contributions	
Plant height (cm)	4.00
Number of leaves	0.27
Total dry matter (g)	0.13
Combined contributions	
Plant height and number of leaves	0.07
Plant height and total dry matter	-0.04
Number of leaves and total dry matter	-0.06
Residual	95.63
Total	100.0%

Table 47: The percentage contributions of different yield components to total fruit yield (t/ha) in 1996 wet season at Samaru.

Individual contributions	
Number of flowers	1.93
Average fruit weight (g)	2.65
Yield per plant (kg)	43.6
Combinal contributions	
Number of flowers and Average fruit weight	2.82
Number of flowers and yield per plant	14.3
Average fruit weight and yield per plant	15.0
Residual	19.7
Total	100.0%

Table 48: Polynomial response of total fruit yield (t/ha) to inter- and intra-row spacings in 1995 wet seaon at Samaru.

Treatment	Linear			Quadratic	
	0	E	X^2	E	X^2
Inter-row spacings(cm)					
45	27.7	27.8	0.004	27.7	0
60	24.8	24.5	0.004	24.8	0
75	20.1	21.2	0.060	21.4	0.080
			$\Sigma X^2$0.068NS		$\Sigma X^2$0.080NS
Intra-row spacings (cm)					
30	27.2	27.6	0.006	27.2	0
45	25.2	24.5	0.020	25.2	0
60	20.2	21.5	0.079	21.2	0.047
			$\Sigma X^2$0.105NS		$\Sigma X^2$0.047NS

Regression equations:

Inter-riow spacing YL = 37.8 - 0.22131x; YQ = 31.6 - 0.004923X - 0.0018032x^2

Intra-row spacing YL = 33.6 - 0.20148x; YQ = 25.2 + 0.2035624x - 0.0045005x^2

0 = Observed value
E = Expected value
X^2 = Chi-square value
NS = Not significant

Table 49: Polynomial response of total fruit yield (t/ha) to inter- and intra-row spacings in 1996 wet season at Samaru.

Treatment	Linear			Quadratic	
	0	E	X^2	E	X^2
Inter-row spacings(cm)					
45	24.4	19.4	1.289	25.0	0.076
60	22.4	17.9	1.131	25.0	0.270
75	20.0	16.4	0.790	24.0	0.667
			ΣX^2 3.210NS		ΣX^2 1.013NS
Intra-row spacings (cm)					
30	24.8	19.4	1.503	21.6	0.474
45	22.6	17.9	1.234	21.5	0.056
60	20.1	16.5	0.785	21.0	0.035
			ΣX^2 3.522NS		ΣX^2 0.565NS

Regression equations:

Inter-riow spacing YL = 24.0 - 0.10167x; YQ = 26.7+ - 0.015476X - 0.0005019x

Intra-row spacing YX = 21.0 - 0.038331x - 0.006296 x

0 = Observed value
E = Expected value
X^2 = Chi-square value
NS = Not significant

4.2 DRY SEASON TRIALS (1995/96 AND 1996/97)

4.2.1 Plant height.

Tables 50 and 51 show the effects of inter-and intra-row spacings on the height of the four tomato varieties during the dry seasons of 1995/96 and 1996/97, respectively. The plant height ranged from 16.7cm at 3 WAT to 39.3cm at 9 WAT in 1995/96 and 15.9cm at 3 WAT to 49.3cm at 9 WAT in 1996/97. The four tomato varieties differ significantly in their height. at 3 and WAT in 1995/96 and at 6 and 9 WAT in 1996/97. At 3 and 6 WAT, *variety TI 468 was the tallest followed by TI 106, TI 182 and 53* which were at par with each other in 1995/96. At 6 WAT in 1996/97 TI 468 was also the tallest followed by TI 106 and 182 which were at par and significantly taller than TI 539. Also in 1996/97 at 9 WAT, TI, 468 was significantly the tallest variety followed by TI 106, TI 182 and TI 539 in that order. In 1995/96 at 9 WAT and in 1996/97 at 3 WAT, there was no significant difference in height among the tomato varieties.

In 1995/96 plant height was not significantly affected by either the inter- or the intra-row spacings at 3 WAT. However, at 6 and 9 WAT the last two levels of inter- and intra-row spacings (60, 45cm and 45 & 30cm, respectively) produced the tallest plants when compared with 75cm inter- and 60cm intra-row spacing levels. In 1996/97 plant height was not significantly affected by either the inter- or the intra-row spacings at all the stages of observations (sampling periods).

No interaction was found to be significant at any of the sampling periods in both the dry seasons (like in the wet seasons).

Table 50 : Effect of inter- and intra-row spacings on plant height (cm) of four tomato varieties during the 1995/96 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	17.4b	28.0b	35.3
TI 182	16.7b	27.6b	33.0
TI 468	19.6a	31.5a	39.3
TI 539	17.4b	29.5b	35.3
SE ±	0.57	0.68	1.15
Inter-row spacings (cm)			
45	18.0	29.8a	37.4a
60	18.4	29.3a	36.3a
75	17.1	28.2b	33.2b
SE ±	0.38	0.51	1.00
Intra-row spacings (cm)			
30	17.8	29.9a	37.8a
45	18.0	29.0a	36.1a
60	17.6	28.5b	32.6b
SE ±	0.38	0.51	1.00
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 51 : Effect of inter- and intra-row spacings on plant height (cm) of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	17.5	27.8b	38.8b
TI 182	16.0	26.0b	34.5c
TI 468	16.0	34.1a	49.3a
TI 539	15.9	24.0c	31.5d
SE ±	0.57	0.56	1.03
Inter-row spacings (cm)			
45	16.7	29.5	39.8
60	16.2	27.2	38.0
75	16.2	27.8	37.7
SE ±	0.35	0.84	1.30
Intra-row spacings (cm)			
30	16.8	28.6	39.9
45	16.2	28.0	38.1
60	16.2	27.8	37.5
SE ±	0.35	0.84	1.30
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.2 Number of leaves.

No significant difference in the number of leaves per plant was observed among the four tomato varieties at 3 WAT in 1995/96 and at 3 and 6 WAT in 1996/97 (Tables 52 and 53 respectively). In 1995/96, TI 468 produced the highest leaf number than the other three varieties (which were at par with each other) at both 6 and 9 WAT. In 1996/97, however, TI 106 and 539 produced significantly higher number of leaves than TI 182 and TI 468 which produced similar leaf number at 9 WAT. The number of leaves ranged from 5 - 6 at 3 WAT, 16-18 at 6 WAT and 30-38 in 1995/96 while it ranged from 6-7 at 3 WAT, 22 - 23 at 6 WAT and 36 - 46 at 9 WAT in 1996/97.

Inter-row spacing significantly influenced the number of leaves at 6 and 9 WAT in the 1995/96 dry season, with 75 and 60cm producing similar and significantly higher number of leaves than the 45cm inter-row spacing. At 3 WAT leaf number was not affected by the inter-row spacing in 1995/96.

Intra-row spacing failed to have any significant effect on number of leaves at 3 and 6 WAT in 1995/96. However, at 9 WAT 60 and 45cm intra-row spacing produced similar and significantly more leaves than 30cm.

In 1996/97 both inter and intra-row spacing had no significant effect on the number of leaves produced by the four tomato varieties.

All interactions were not significant during both dry seasons.

Table 52 : Effect of inter- and intra-row spacings on number of leaves per plant of four tomato varieties during the 1995/96 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	5.60	15.6b	29.6b
TI 182	5.44	15.6b	31.1b
TI 468	5.42	17.6a	38.1a
TI 539	5.98	15.7b	33.1b
SE ±	0.12	0.64	1.70
Inter-row spacings (cm)			
45	5.6	15.5b	30.4b
60	5.7	18.2a	33.6a
75	5.5	18.6a	34.8a
SE ±	0.08	0.44	1.02
Intra-row spacings (cm)			
30	5.67	15.9	30.3b
45	5.77	15.2	33.2a
60	5.59	17.2	34.2a
SE ±	0.08	0.44	1.02
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 53 : Effect of inter- and intra-row spacings on number of leaves per plant of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	6.08	23.4	43.4a
TI 182	6.05	21.8	36.3b
TI 468	5.81	22.1	39.5b
TI 539	6.66	22.7	46.2a
SE ±	0.25	0.94	1.26
Inter-row spacings (cm)			
45	5.93	22.9	41.7
60	6.87	24.3	41.4
75	5.95	22.8	42.4
SE ±	0.08	1.00	1.39
Intra-row spacings (cm)			
30	6.33	22.8	40.6
45	6.50	22.6	41.5
60	5.93	22.0	43.4
SE ±	0.32	1.00	1.39
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.3 Leaf Area Index (LAI).

Significant differences in LAI among the four tomato varieties were observed at all the sampling periods in both 1995/96 and 1996/97 (Tables 54 and 55, respectively). At 3 WAT varieties TI 106 and 539 had significantly similar and higher LAI than TI 182 followed by TI 468, during both dry seasons. At 6 and 9 WAT, during both dry seasons, TI 539 had significantly higher LAI followed by TI 106 which, in turn was significantly higher than TI 182 and 468, with the two being at par.

Inter-row spacing significantly influenced LAI at all the sampling periods and in both dry seasons with 45cm recording the highest LAI followed by 60cm and then 75cm spacing in that order.

Intra-row spacing also significantly affected the LAI, at all the sampling periods and both dry seasons with 30cm recording the highest LAI followed by 45cm and then 60cm spacing in that order.

Like in the wet season trials, for both the inter and intra-row spacings, the trend is that the closer the spacing, the higher the LAI.

Interaction between inter and intra-row spacings at 3WAT in 1995/96 was observed to be significant (Table 56). It revealed that the wider the spacing the least will be the LAI and vice varsa. Interaction between inter-row spacing and variety in 1995/96 at 3 WAT which was also significant showed that TI 106 and TI 468 had similar LAI at their respective 45 and 60cm inter-row spacing which was significantly higher than that at 75cm

Table 55: Effect of inter- and intra-row spacings on leaf area index of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	0.46a	3.86b	7.86b
TI 182	0.25b	2.78c	6.44c
TI 468	0.19c	2.97c	6.23c
TI 539	0.48a	5.57a	16.3a
SE ±	0.004	0.09	0.32
Inter-row spacings (cm)			
45	0.37a	4.33a	10.2a
60	0.32b	4.02b	8.57b
75	0.25c	2.68c	7.02c
SE ±	0.004	0.10	0.30
Intra-row spacings (cm)			
30	0.45a	5.10a	12.3a
45	0.27b	3.46b	8.01b
60	0.24c	2.57c	7.11c
SE ±	0.004	0.10	0.30
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NN	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are *significantly different at 5% level of significance using DMRT.*

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 56: Interaction of inter x intra-row spacings on leaf area index of tomato at 3 WAT during the 1995/96 dry season at Samaru.

Treatment	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	0.37a	0.24c	0.18de
60	0.31b	0.20d	0.17ef
75	0.26c	0.16efg	0.14g
SE ±	0.006		

Table 57: Interaction of inter-row spacing x variety on leaf area index of tomato at 3 WAT during the 1995/96 dry season at Samaru.

Treatments	Inter-row spacing (cm) 45	60	75
Variety			
TI 106	0.32b	0.31b	0.24d
TI 182	0.23d	0.19e	0.16f
TI 468	0.15f	0.14f	0.10g
TI 539	0.34a	0.28c	0.24d
SE ±	0.008		

Table 58: Interaction of intra-row spacing x variety on leaf area index of tomato at 3 WAT during the 1995/96 dry season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	0.39b	0.27c	0.21d
TI 182	0.26c	0.17e	0.14f
TI 468	0.18e	0.12g	0.09h
TI 539	0.42a	0.25c	0.22d
SE ±	0.008		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.2.4 Total Dry Matter (TDM).

In both 1995/96 and 1996/97 the four tomato varieties differ significantly in their total dry matter (TDM) only at 3 WAT (Tables 59 and 60, respectively), with TI 468 producing higher TDM than the other three varieties, which were at par with each other. At 6 and 9 WAT during both dry seasons there were no significant differences in TDM among the four tomato varieties.

Also like the wet season in both 1995/96 and 1996/97, inter-row spacings affected TDM significantly only at 6 WAT, with the 75cm spacing tomatoes having significantly higher TDM than those at 60 and 45cm spacings whose TDM were at par with each other.

Like the inter-row spacings, and also like in the wet seasons, the intra-row spacings also affected the tomato TDM only at 6 WAT in both 1995/96 and 1996/97 dry seasons. Tomatoes planted at 60cm intra-row spacing had significantly more TDM than those planted at 45 and 30cm which were at par with each other.

Significant interactions on TDM between inter and intra-row spacings at 6 WAT and intra-row spacing and variety at 6 WAT were observed to be significant in 1995/96 (Tables 61 and 62, respectively). The interaction between inter and intra-row spacing showed that at 75cm inter-row spacing, 60 and 45cm intra-row spacing produced similar and significantly higher TDM than 30cm intra-row spacing (Table 61). At 60 and 45cm spacing inter-row spacing, the wider the intra-row spacing the higher the TDM. The interaction between intra-row spacing and variety showed that TI 106, TI 468 and TI 539 produced similar TDM in their

respective 60 and 45cm intra-row spacing which was significantly higher than the TDM at 30cm (Table 62). For TI 182 the wider the intra-row spacing the higher the TDM. TDM for all the varieties was similar at the 30cm intra-row spacing. All treatment interactions on TDM during the 1996/97 were not significant.

Table 59: Effect of inter- and intra-row spacings on total dry matter (g) of four tomato varieties during the 1995/96 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	1.01b	2.94	24.2
TI 182	1.04b	2.78	22.3
TI 468	1.34a	2.90	21.4
TI 539	1.01b	3.03	21.9
SE ±	0.04	0.11	0.97
Inter-row spacings (cm)			
45	1.15	2.67b	21.6
60	1.15	2.82b	22.2
75	1.03	3.25a	23.6
SE ±	0.04	0.07	1.09
Intra-row spacings (cm)			
30	1.10	2.72b	21.3
45	1.14	2.80b	22.2
60	1.09	3.22a	23.9
SE ±	0.004	0.10	0.30
Interactions			
I x i	NS	*	NS
I x V	NS	NS	NS
i x V	NS	*	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 60: Effect of inter- and intra-row spacings on total dry matter (g) of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 3	6	9
Varieties			
TI 106	1.07b	3.11	25.6
TI 182	1.17b	3.12	25.0
TI 468	1.57a	3.39	25.0
TI 539	1.13b	3.38	24.4
SE ±	0.05	0.13	0.98
Inter-row spacings (cm)			
45	23.0	3.04b	1.22
60	25.2	3.20b	1.31
75	26.8	3.69a	1.17
SE ±	0.05	0.08	1.22
Intra-row spacings (cm)			
30	24.1	3.02b	1.26
45	24.4	3.08b	1.25
60	26.6	3.58a	1.21
SE ±	0.05	0.08	0.22
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 61: Interaction of inter x intra-row spacings on total dry matter (g) of tomato at 6 WAT during the 1995/96 dry season at Samaru.

Treatment	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	2.04d	2.51c	2.98b
60	2.01d	2.54c	2.90b
75	3.04b	3.29a	3.78a
SE ±	0.13		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 62: Interaction of intra-row spacing x variety on total dry mater (g) of tomato at 6WAT during the 1996/97 dry season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	2.66c	3.31a	3.13a
TI 182	2.43c	2.92b	3.65a
TI 468	2.58c	2.83bc	2.94b
TI 539	2.68c	2.88b	3.26ab
SE ±	0.19		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.2.5 Relative Growth Rate (RGR).

RGR at 6 and 9 WAT as affected by inter and intra-row spacings of the four tomato varieties at Samaru during the 1995/96 and 1996/97 dry seasons are shown in Tables 63 and 64, respectively. At 6 WAT during both dry seasons TI 468 had significantly higher RGR than TI 106 followed by TI 182 and then TI 539 with the least RGR in that order. At 9 WAT in 1995/96 TI 468 and TI 539 had similar and significantly higher RGR than TI 106 which, in turn, was also significantly, higher than TI 182. At 9 WAT in 1996/97 TI 468, 539 and 106 had similar and significantly higher RGR than TI 182.

In both 1995/96 and 1996/97, inter-row spacings significantly affected RGR at both the sampling periods. In 1995/96 at 6 WAT, 45 and 60cm had similar and significantly higher RGR than 75cm spacing; while at 9 WAT 45cm inter-row spacing had significantly higher RGR than 60cm which was also significantly higher than the 75cm spacing. In 1996/97, at both sampling periods 45cm inter-row spacing had significantly higher RGR than the 60cm and 75cm spacings which were at par with each other.

The intra-row spacings also significantly affected the RGR of the tomatoes at both sampling periods and in both years of the trial. In 1995/96, at 6 WAT 30 and 45cm spacings had similar and significantly higher RGR than 60cm intra-row spacing. While at 9 WAT in the same year it was observed that the closer the intra-row spacing the higher the RGR. In 1996/97, at both sampling

periods, the 30cm intra-row spacing had significantly higher RGR than the 45 and 60cm spacings which were at par with each other.

None of the interactions was significant in both dry seasons.

Table 63: Effect of inter- and intra-row spacings on relative growth rate (g/g/wk) of four tomato varieties during the 1995/96 dry season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	0.74b	0.28b
TI 182	0.67c	0.25c
TI 468	0.84a	0.30a
TI 539	0.62d	0.31a
SE ±	0.01	0.006
Inter-row spacings (cm)		
45	0.76a	0.31a
60	0.75a	0.24b
75	0.65b	0.22c
SE ±	0.01	0.006
Intra-row spacings (cm)		
30	0.75a	0.30a
45	0.73a	0.25b
60	0.70b	0.22c
SE ±	0.01	0.006
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 64: Effect of inter- and intra-row spacings on relative growth rate (g/g/wk) of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	0.84b	0.31a
TI 182	0.74c	0.28b
TI 468	0.95a	0.32a
TI 539	0.66d	0.31a
SE ±	0.01	0.005
Inter-row spacings (cm)		
45	0.86a	0.38a
60	0.77b	0.27b
75	0.77b	0.26b
SE ±	0.02	0.001
Intra-row spacings (cm)		
30	0.85a	0.31a
45	0.77b	0.27b
60	0.72b	0.25b
SE ±	0.02	0.01
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.6 Net Assimilation Rate (NAR).

In both 1995/96 and 1996/97 dry seasons, the four tomato varieties differ significantly in their NAR at both sampling periods (Tables 65 and 66, respectively). In 1995/96, at 6 WAT TI 106 had significantly higher NAR followed by TI 182, TI 468 and TI 539 in that order of significance; while at 9 WAT TI 106 had also the highest NAR followed by the other three tomato varieties with were at par with each other. In 1996/97 at both sampling periods, TI 106 and 468 had similar and significantly higher NAR followed by TI 182 which in turn, also had significantly higher NAR than TI 539.

At 6 WAT in both dry seasons, 45cm inter-row spacing recorded significantly higher NAR than 60cm which, in turn also recorded significantly higher NAR than 75cm. Also at 9 WAT in both dry seasons, 45cm inter-row spacing recorded significantly the highest NAR than 60 and 75cm which, this time, were at par with each other.

In 1995/96 at 6 WAT 30 and 45cm intra-row spacings had similar and significantly higher NAR than 60cm spacing. At 9 WAT in 1995/96 and at both 6 and 9 WAT in 1996/97, 30cm intra-row spacing gave significantly the highest NAR followed by 45cm and then 60cm spacing in that order of significance.

Like in the wet season trials, none of the interactions was also observed to be significant.

Table 65: Effect of inter- and intra-row spacings on net assimilation rate ($g/cm^2/wk$) of four tomato varieties during the 1995/96 dry season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	2.94a	0.63a
TI 182	2.58b	0.49b
TI 468	2.07c	0.43b
TI 539	1.03d	0.47b
SE ±	0.04	0.02
Inter-row spacings (cm)		
45	2.43a	0.84a
60	2.20b	0.39b
75	1.83c	0.37b
SE ±	0.03	0.01
Intra-row spacings (cm)		
30	2.31a	0.73a
45	2.26a	0.50b
60	1.89b	0.28c
SE ±	0.02	**0.01**
Interactions		
I x i	NS	**NS**
I x V	NS	**NS**
i x V	NS	**NS**
I x i x V	NS	**NS**

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 66: Effect of inter- and intra-row spacings on net assimilation rate ($g/cm^2/wk$) of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 6	9
Varieties		
TI 106	4.63a	0.91a
TI 182	2.89b	0.71b
TI 468	4.74a	0.98a
TI 539	1.13c	0.52c
SE ±	0.05	0.03
Inter-row spacings (cm)		
45	3.19a	1.10a
60	3.03b	0.54b
75	2.56c	0.52b
SE ±	0.05	0.02
Intra-row spacings (cm)		
30	3.94a	1.25a
45	2.75b	0.61b
60	2.13c	0.32c
SE ±	0.05	0.02
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.7 Number of flowers.

Tables 67 and 68 show the effect of inter and intra-row spacings on the number of flowers per plant of the four tomato varieties at 5, 6 and 7 WAT in 1995/96 and 1996/97 dry seasons, respectively. In 1995/96 the varieties differ significantly at 5 WAT while no significant difference was observed at 6 and 7 WAT. TI 106 and 539 produced similar and significantly higher number of flowers per plant than TI 182 and 468 which were at par with each other in 1995/96 at 5WAT. In 1996/97 the varieties differ significantly in number of flowers produced per plant at all the sampling periods with TI 106 and 539 being at par and producing significantly higher number of flowers than TI 182 which, in turn was also significantly higher than TI 468.

Both inter- and intra-row spacings had no significant effect on number of flowers produced per plant during the two dry season trials.

Significant interaction was recorded between intra-row spacing and variety at 6 WAT in 1996/97 (Table 69). At all intra-row spacing levels, TI 539 had significantly higher number of flowers per plant than TI 106 which, in turn also had significantly higher number of flowers per plant than varieties TI 182 and TI 468 which were at par. Also varieties TI 106, TI 182 and TI 468 had similar and significantly higher number of flowers in their respective 45 and 60cm than at 30cm. TI 539 had similar flower number at all the intra-row spacing levels.

Table 67: Effect of inter- and intra-row spacings on number of flowers per plant of four tomato varieties during the 1995/96 dry season at Samaru.

Treatments	Weeks After Transplanting 5	6	7
Varieties			
TI 106	6.32a	11.8	21.8
TI 182	4.94b	11.0	21.3
TI 468	4.21b	10.5	19.9
TI 539	5.43a	11.8	21.7
SE ±	0.42	0.76	1.55
Inter-row spacings (cm)			
45	4.80	11.0	20.3
60	5.39	11.1	20.9
75	5.40	11.7	22.5
SE ±	0.34	0.61	1.02
Intra-row spacings (cm)			
30	4.99	10.8b	20.2
45	5.38	11.8	21.3
60	5.23	11.3	22.1
SE ±	0.34	0.61	1.02
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	NS	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively. V = Varieties.

Table 68: Effect of inter- and intra-row spacings on number of flowers per plant of four tomato varieties during the 1996/97 dry season at Samaru.

Treatments	Weeks After Transplanting 5	6	7
Varieties			
TI 106	9.15a	25.7a	34.3a
TI 182	7.31b	21.4b	28.7b
TI 468	6.01c	18.6c	20.2c
TI 539	9.17a	26.6a	37.1a
SE ±	1.12	0.68	1.12
Inter-row spacings (cm)			
45	7.61	21.7	30.4
60	8.03	21.5	32.9
75	5.79	20.8	31.4
SE ±	0.65	1.41	1.30
Intra-row spacings (cm)			
30	7.12	21.9	31.0
45	7.44	21.3	32.2
60	7.87	20.8	31.6
SE ±	0.65	1.41	1.30
Interactions			
I x i	NS	NS	NS
I x V	NS	NS	NS
i x V	NS	*	NS
I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 69: Interaction of intra-row spacing x variety on number of flowers per of tomato at 6 WAT during the 1996/97 dry season at Samaru.

	Intra-row spacing (cm)		
Treatments	30	45	60
Variety			
TI 106	19.9c	23.9b	24.4b
TI 182	16.1d	20.1c	20.4c
TI 468	16.0d	20.2c	20.6c
TI 539	25.8ab	28.7a	25.4ab
SE ±	1.18		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.2.8 Days to 50% flowering.

Significant difference among the four tomato varieties were observed in terms of the number of days to 50% flowering, with TI 106 flowering significantly much earlier than all the three other varieties, which flowered similarly in both 1995/96 and 1996/97 (Table 70).

Tomato plants spaced at inter-row spacings of 75 and 60cm attained days to 50% flowering similarly much earlier and significantly better than those spaced at 45cm in both dry seasons.

A similar trend was also followed by the intra-row spacing levels in both dry seasons, with tomato plants spaced at 60 and 45cm intra-row spacings attaining days to 50% flowering much earlier and significantly better than those spaced at 30cm.

Interactions between the various treatments were all not significant in both dry seasons.

Table 70: Effect of inter- and intra-row spacings on days to 50% flowering of four tomato varieties during the 1995/96 and 1996/97 dry season at Samaru.

Treatments	Days to 50% flowering 1995/96	1996/97
Varieties		
TI 106	47.3b	49.8b
TI 182	53.4a	55.6a
TI 468	54.2a	55.2a
TI 539	53.4a	54.9a
SE ±	0.60	0.81
Inter-row spacings (cm)		
45	55.3a	54.8a
60	51.6b	53.2b
75	50.4b	52.4b
SE ±	0.42	0.53
Intra-row spacings (cm)		
30	57.2a	54.9a
45	50.4b	53.3b
60	50.7b	52.3b
SE ±	0.42	0.53
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.9 Number of days to first harvest (picking).

Significant differences among the four tomato varieties were also observed interms of the number of days to first harvest (Tale 71). In 1995/96 TI 106 was picked (harvested) significantly much earlier than TI 182 followed by TI 468 which was also followed by TI 539 in that order of significance. In 1996/97, TI 106 was also picked significantly much earlier than TI 182 followed by TI 468 and 539, which had similar picking dates.

During both dry seasons, tomato plants spaced at 75 and 60cm inter-row spacings were first harvested significantly much earlier than those spaced at 45cm.

A similar trend was also followed by the intra-row spacing levels in both dry seasons, with tomato plants spaced at 60 and 45cm intra-row spacings being first harvested significantly much earlier than those planted at 30cm spacing.

The interaction were also similarly not significant like in the wet seasons.

Table 71: Effect of inter- and intra-row spacings on days to first harvest of four tomato varieties during the 1995/96 and 1996/97 dry seasons at Samaru.

Treatments	Days to first harvest 1995/96	1996/97
Varieties		
TI 106	84.4d	85.3c
TI 182	88.4c	89.6b
TI 468	93.3b	94.2a
TI 539	95.8a	97.8a
SE ±	1.20	1.31
Inter-row spacings (cm)		
45	94.1a	93.2a
60	91.8b	89.4b
75	91.3b	89.7b
SE ±	1.02	1.24
Intra-row spacings (cm)		
30	94.3a	94.2a
45	91.2b	90.1b
60	90.8b	90.4b
SE ±	1.02	1.24
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.10 Fruit Firmness.

Table 72 shows the effect of the various treatments on the firmness of the fruits of the four tomato varieties in both dry seasons. In 1995/96, the fruits of varieties TI 106 and TI 539 were at par and significantly more firm than those of TI 182, which in turn had fruits that were significantly more firm than those of TI 468. In 1996/97, the fruits of TI 539 were also significantly more firm than those of TI 106 followed by TI 182, whose fruits were also significantly more firm than those of TI 468.

In 1995/96, the inter-row spacing levels failed to have any significant effect on fruit firmness of the four tomato varieties. However, in 1996/97, 75 and 60cm inter-row spacings gave significantly and similarly more firm fruits than the 45cm spacing.

Intra-row spacings of 60 and 45cm were observed to have similar and significantly firmer fruits than those fruits on tomato plants spaced at 30cm in both dry seasons.

Interaction between intra-row spacing and variety in 1995/96 was observed to be significant (Tabled 73). For varieties TI 106, TI 182 and TI 539 the wider the intra-row spacing the more firm the fruits. On the other hand, TI 468 was unaffected by the changes in the spacing levels. The interaction between inter-row spacing and variety in 1996/97 which was significant (Table 74) revealed that for variety TI 182 and TI 539 the wider the inter-row spacing (60 and 75cm) the more firm the fruits. On the other hand, TI 106 and TI 468 where unaffected by changes in the inter-row spacing levels.

Table 72: Effect of inter- and intra-row spacings on fruit firmness (°0) of four tomato varieties during the 1995/96 and 1996/97 dry seasons at Samaru.

Treatments	Fruit firmness (°0) 1995/96	1996/97
Varieties		
TI 106	89.8a	122.4b
TI 182	81.4b	115.5c
TI 468	60.4c	72.3d
TI 539	92.5a	150.3a
SE ±	1.51	1.86
Inter-row spacings (cm)		
45	82.2	108.7b
60	80.3	116.9a
75	80.6	119.8a
SE ±	1.48	1.64
Intra-row spacings (cm)		
30	79.0b	109.7b
45	84.3a	121.6a
60	85.6a	118.2a
SE ±	1.48	1.64
Interactions		
I x i	NS	NS
I x V	NS	*
i x V	*	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 73: Interaction of intra-row spacing x variety on fruit firmness (°0) of tomato during the 1995/96 dry season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	79.8cd	92.5ab	97.3a
TI 182	76.3d	81.1cd	86.9bc
TI 468	59.6e	60.2e	64.5e
TI 539	87.2b	90.4b	98.8a
SE ±	2.62		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 74: Interaction of inter-row spacing x variety on fruit firmness of tomato during the 1996/97 dry season at Samaru.

Treatments	Inter-row spacing (cm) 45	60	75
Variety			
TI 106	123.0c	124.0c	125.6c
TI 182	111.0d	123.5c	125.1c
TI 468	72.3e	76.1e	76.3e
TI 539	139.4b	155.3a	155.8a
SE ±	3.21		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.2.11 Percent soluble solids.

The effects of the treatments on the percent soluble solids are shown in Table 75. The four tomato varieties differ significantly in their soluble solids in both 1995/96 and 1996/97 with variety TI 468 having significantly more soluble solids in its fruits than the other three varieties which have statistically similar soluble solids in their fruits.

Inter-row spacing was observed to have no significant effect on the percent soluble solids of the four tomato varieties in both dry season trials.

It was only during the 1996/97 dry season that intra-row spacing significantly affected the amount of soluble solids in the four tomato varieties, with those plants spaced at 30cm having significantly higher soluble solids in their fruits than those at 45 and 60cm intra-row spacings which had statistically similar soluble solids.

Interactions between intra-row spacing and variety in both years were observed to be significant (Tables 76 and 77, respectively). In 1995/96 percent soluble solids of TI 106 and TI 539 were unaffected by the differences in intra-row spacing levels (Table 76). Variety TI 182 had similar and significantly higher percent soluble solids at 30 and 45cm than at 60cm intra-row spacing while variety TI 468 had significantly higher percent soluble solids at 30cm than at 45 and 60cm intra-row spacing which were at par. In 1996/97 variety TI 106 had similar and significantly higher percent soluble solids at 30 and 45cm intra-

row spacing than at 60cm (Table 77). For TI 182 the closer the intra-row spacing the higher the percent soluble solids. TI 468 had significantly higher percent soluble solids at 30cm than at 45 and 60cm intra-row spacing which were at par. Here also the percent soluble solids of TI 539 was unaffected by the various intra-row spacing levels.

Table 75: Effect of inter- and intra-row spacings on percent soluble solids (%) of four tomato varieties during the 1995/96 and 1996/97 dry seasons at Samaru.

Treatments	Percent soluble solids (%) 1995/96	1996/97
Varieties		
TI 106	0.47b	0.57b
TI 182	0.51b	0.51b
TI 468	1.64a	1.82a
TI 539	0.46b	0.57b
SE ±	0.08	0.05
Inter-row spacings (cm)		
45	0.74	0.82
60	0.77	0.87
75	0.80	0.92
SE ±	0.07	0.04
Intra-row spacings (cm)		
30	0.95	1.16a
45	0.70	0.74b
60	0.68	0.70b
SE ±	1.07	0.04
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	*	*
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 76: Interaction of intra-row spacing x variety on percent solubles solids (%) of tomato during the 1995/96 dry season at Samaru.

Treatments	Intra-row spacing (cm)		
	30	45	60
Variety			
TI 106	0.49c	0.53c	0.39c
TI 182	0.63c	0.53c	0.28d
TI 468	2.17a	1.46b	1.29b
TI 539	0.52c	0.46c	0.41c
SE ±	0.06		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 77: Interaction of intra-row spacing x variety on percent solubles solids (%) of tomato during the 1996/97 dry season at Samaru.

Treatments	Intra-row spacing (cm)		
	30	45	60
Variety			
TI 106	0.74c	0.71c	0.52d
TI 182	0.70c	0.51d	0.21e
TI 468	2.73a	1.46b	1.26b
TI 539	0.65cd	0.54d	0.52d
SE ±	0.09		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.2.12 Average Fruit Weight.

Varieties TI 106, TI 468 and TI 539 recorded similar and significantly heavier fruits than TI 182 in both 1995/96 and 1996/97 dry seasons (Table 78).

Both inter and intra-row spacings had no significant effect on fruit weight of the four tomato varieties during both the 1995/96 and 1996/97 dry seasons.

All interaction effects between the various treatments were not significant statistically in both seasons.

4.2.13 Yield per plant.

Table 79 shows the effect of the various treatments on the yield per plant of the four tomato varieties in both dry seasons of the trial. Varieties TI 106, 182 and 539 produced similar and significantly higher yield per plant than TI 468 in the 1995/96 dry season. In 1996/97 dry season TI 106 and 539 were at par and had significantly higher yield per plant than TI 182 and 468 which were also at par with each other.

During both seasons, the two higher inter and intra-row spacing levels (75 and 60cm and 60 and 45cm, respectively) had similar and significantly higher fruit yield per plant than the least inter and intra-row spacing levels of 45 and 30cm, respectively.

All interaction affects between the various treatments were not significant statistically in both dry seasons.

Table 78: Effect of inter- and intra-row spacings on average fruit weight (g) of four tomato varieties during the 1995/96 and 1996/97 dry seasons at Samaru.

Treatments	Average fruit weight (g) 1995/96	1996/97
Varieties		
TI 106	43.2a	39.4a
TI 182	34.0b	36.4b
TI 468	44.6a	39.7a
TI 539	43.2a	40.4a
SE ±	1.56	1.02
Inter-row spacings (cm)		
45	41.4	38.1
60	41.8	38.8
75	42.0	39.4
SE ±	0.84	1.26
Intra-row spacings (cm)		
30	41.0	38.7
45	41.2	38.8
60	43.0	38.8
SE ±	0.84	1.26
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 79: Effect of inter- and intra-row spacings on yield per plant (kg) of four tomato varieties during the 1995/96 and 1996/97 dry seasons at Samaru.

Treatments	Yield per plant (kg) 1995/96	1996/97
Varieties		
TI 106	0.69a	1.29a
TI 182	0.63a	0.99b
TI 468	0.39b	0.98b
TI 539	0.66a	1.26a
SE ±	0.04	0.07
Inter-row spacings (cm)		
45	0.58b	0.79b
60	0.65a	1.04a
75	0.66a	1.06a
SE ±	0.02	0.09
Intra-row spacings (cm)		
30	0.50b	0.82b
45	0.64a	1.09a
60	0.69a	1.16a
SE ±	0.02	0.09
Interactions		
I x i	NS	NS
I x V	NS	NS
i x V	NS	NS
I x i x V	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

4.2.14 Total Fruit Yield.

The fruit yield ranged between 19.4 and 68.9t/ha (Table 80). In 1995/96 varieties TI 539, 106 and 182 had similar and significantly higher fruit yield than TI 468 while in 1996/97 TI 539 had significantly the highest fruit yield followed by TI 106 and 182 which were at par and significantly higher than TI 468.

The 45 and 60cm inter-row spacing also resulted in statistically better fruit yield than the 75cm spacing in both the 1995/96 and 1996/97 dry seasons.

Similarly, the 30 and 45cm intra-row spacings were significantly better than the 60cm spacing in the two dry seasons.

All interaction effects (with the exception of second order of interaction in 1995/96 dry season) between the various treatments were significant statistically in both dry seasons. The interaction between inter and intra-row spacings in 1995/96 showed that at 75cm inter-row spacing, intra-row spacing had no significant effect on total fruit yield (Table 81). At 45 and 60 cm inter-row spacings, 30 and 45cm intra-row spacings produced similar and significantly higher total fruit yield than at 60cm intra-row spacing. In 1996/97, interaction between inter- and intra-row spacing showed that at 45 and 75cm inter-row spacing, intra-row had no significant effect on total fruit yield (Table 82). At 60cm inter-row spacing, 30 and 45cm intra-row spacing had significantly higher total fruit yield per hectare than at 60cm intra-row spacing. The interaction between inter-row spacing

and variety on total fruit yield in 1995/96 showed that varieties TI 106, TI 182 and TI 468 had similar total fruit yield in their respective inter-row spacing levels (Table 83). TI 539 on the other hand, had significantly higher total fruit yield at 45cm than at 60 and 75cm inter-row spacings, which were at par with each other. The interaction between inter-row spacing and variety on total fruit yield in 1996/97 showed that TI 106 had similar and significantly higher fruit yield per hectare at 45 and 60cm than at 75cm inter-row spacing (Table 84). TI 182 was unaffected by the changes in inter-row spacing levels. For TI 468, the wider the inter-row spacing the higher the total fruit yield while for TI 539 the closer the inter-row spacing the higher the total fruit yield.

The interaction between intra-row spacing and variety in 1995/1996 showed that total fruit yield of TI 106 and TI 468 were unaffected by the intra-row spacing levels (Table 85). TI 182 had significantly higher total fruit yield at 45cm than at 30 and 60cm intra-row spacing, which were similar. For TI 539 the closer the intra-row spacing the higher the total fruit yield. The interaction between intra-row spacing and variety on total fruit yield in 1996/97 showed that, here, TI 106 was also unaffected by the variation in the intra-row spacing levels (Table 86). For TI 182, the closer the intra-row spacing the higher the total fruit yield. TI 468 had similar and significantly higher total fruit yield at 45 and 60cm than at 30cm intra-row spacing. TI 539 had similar and significantly

higher total fruit yield at 30 and 45cm than at 60cm intra-row spacing.

The second order of interaction between inter row spacing, intra-row spacing and the tomato varieties in 1996/97 revealed that the highest fruit yield was obtained by 45 x 30cm x TI 539 and the lowest by 45cm x 30cm x TI 468 (Table 87).

Table 80: Effect of inter- and intra-row spacings on total fruit yield (t/ha) of four tomato varieties during the 1995/96 and 1996/97 dry seasons at Samaru.

Treatments season	Total fruit yield (t/ha) 1995/96 dry season	1996/97 dry
Varieties		
TI 106	35.3a	59.0b
TI 182	34.3a	55.2b
TI 468	19.4b	45.7c
TI 539	35.5a	68.9a
SE ±	2.13	2.98
Inter-row spacings (cm)		
45	34.5a	65.6a
60	31.2a	61.4a
75	27.1b	43.1b
SE ±	1.35a	4.07
Intra-row spacings (cm)		
30	34.4a	61.4a
45	30.6a	59.8a
60	26.2b	47.5b
SE ±	1.35	3.07
Interactions		
I x i	*	*
I x V	*	*
i x V	*	*
I x i x V	NS	*

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

* = Significant at 5% level of significance
NS = Not significant. I and i = inter-and intra-row spacings, respectively.
V = Varieties.

Table 81: Interaction of inter x intra-row spacings on total fruit yield (t/ha) of tomato during the 1995/96 dry season at Samaru.

Treatment	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	41.7a	42.8a	31.2bc
60	43.2a	43.8a	33.0bc
75	28.0bcd	26.0cd	24.9d
SE ±	2.31		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 82: Interaction of inter x intra-row spacings on total fruit yield (t/ha) of tomato during the 1996/97 dry season at Samaru.

Treatment	Intra-row spacing (cm) 30	45	60
Inter-row spacing (cm)			
45	75.6a	61.3ab	68.0abc
60	68.8ab	68.0ab	47.0c
75	39.1d	50.1bcd	39.2d
SE ±	7.04		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 83: Interaction of inter-row spacing x variety on total fruit yield (t/ha) of tomato during the 1995/96 dry season at Samaru.

Treatments	Inter-row spacing (cm) 45	60	75
Variety			
TI 106	31.2b	37.8ab	28.5bc
TI 182	35.7ab	37.5ab	33.0b
TI 468	18.4c	18.9c	20.9c
TI 539	43.8a	31.5b	28.2bc
SE ±	3.66		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 84: Interaction of inter-row spacing x variety on total fruit yield (t/ha) of tomato during the 1996/97 dry season at Samaru.

Treatments	Inter-row spacing (cm) 45	60	75
Variety			
TI 106	66.1b	57.0b	42.0d
TI 182	50.1cd	61.0bc	46.6c
TI 468	41.3d	49.7c	57.9b
TI 539	94.6a	69.8b	42.4d
SE ±	5.16		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 85: Interaction of intra-row spacing x variety on total fruit yield (t/ha) of tomato during the 1995/96 dry season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	29.7bc	37.8ab	29.2bc
TI 182	33.0b	43.5a	29.6bc
TI 468	17.2d	20.1cd	20.9cd
TI 539	43.5a	31.2b	27.8c
SE ±	3.66		

Table 86: Interaction of intra-row spacing x variety on total fruit yield (t/ha) of tomato during the 1996/97 dry season at Samaru.

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	57.4bc	56.1bc	51.6c
TI 182	68.2ab	51.9c	36.5d
TI 468	36.0d	53.5c	57.5bc
TI 539	82.1a	73.6a	51.1c
SE ±	5.16		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 87: Interaction of variety x inter-row x intra-row spacings on total fruit yield (t/ha) of tomato during the 1996/97 dry season at Samaru.

Treatments		Variety			
		TI 106	TI 182	TI 468	TI 539
Inter-row spacing (cm)	Intra-row spacing(cm)				
45	30	62.9cdef	67.2bcde	20.2g	112.0a
	45	68.9bcde	45.0efg	45.4efg	91.8b
	60	67.0bcde	44.0efg	58.3def	70.9bcde
60	30	63.6cdef	50.1defg	46.1g	75.7bcd
	45	66.1cdef	89.6bc	72.3bcd	83.4bc
	60	41.4fg	43.2fg	55.3efg	50.4befg
75	30	40.2fg	47.7efg	42.4fg	49.5defg
	45	46.5efg	60.7def	54.8def	45.5efg
	60	39.2fg	31.3g	46.8ef	32.1g
SE ±		8.90			

Interaction means followed by unlike letter(s) are significantly different at 5 level of significance using DMRT.

4.2.15 Correlation and Path Coefficient Analysis, 1995/96 dry season.

Correlation studies between total fruit yield of tomato and other plant parameters during the 1995/96 dry season are presented in Table 88. There was a very strong positive correlation at 1% level of significance between total fruit yield and yield/plant, average fruit weight, number of flowers/plant (7 WAT), fruit firmness, leaf area index (9 WAT), NAR (6 WAT), number of leaves/plant (9WAT) and plant height (9WAT). Also a very strong but negative correlation at 1% level of significance was observed between total fruit yield and days to 50% flowering. Considering correlation between the major yield components, it was observed that yield/plant was positively and highly significantly correlated to average fruit weight and number of flowers/plant (7 WAT). Average fruit weight was also positively and highly significantly correlated to number of flowers/plant (7WAT).

The direct and indirect contributions of vegetative growth characters on total fruit yield are presented in Table 89 and the path coefficient diagram between total fruit yield and the vegetative growth characters is presented in figure 5. They revealed that plant height contributed directly 20.9% to total fruit yield and indirectly, via number of leaves and total dry matter 0.3% and 0.1%, respectively. Thus, total contribution by plant height to total fruit yield was 21.3%. When the contribution of number of leaves/plant to total fruit yield was

examined. the direct effect was found to be 1.4% and the indirect affects, via plant height and total dry matter were 5.5% and 0.7%, respectively. Thus, the total contribution of number of leaves/plant to total fruit yield was 7.6%. When the total dry matter was investigated for its contribution to total fruit yield, the direct effect was found to be 2.9% and the indirect effects, via plant height and number of leaves were 0.4% and 0.3%, respectively. Thus, the total contribution by total dry matter to total fruit yield was 3.6%.

The direct and indirect contributions of yield characters on total fruit yield of tomato is presented in Table 90 and the path coefficient diagram between total fruit yield and the yield characters is presented in Figure 6. The analyses revealed that number of flowers/plant directly contributed 16.4% to total fruit yield, and indirectly, via average fruit weight and yield/plant contributed 18.6% and 45.6%, respectively. Thus, the total contribution by number of flowers/plant to total fruit yield was 80.6%. When the contribution of average fruit weight to total fruit yield was examined, the direct effect was found to be 29.2% and the indirect effects via number of flowers/plant and yield/plant were 10.4% and 38.7%, respectively. Thus, the total contribution by average fruit weight to total fruit yield was found to be 78.3%. When the yield/plant was investigated for its contribution to total fruit yield, the direct effect was observed to be 58.5% while the indirect effects, via number of flowers/plant and average fruit weight were 12.8% and 19.4%, respectively. Thus, the total contribution by yield/plant to total fruit yield was 90.7%.

Table 88: Matrix of correlation coefficient between tomato fruit yield (t/ha) and various other plant parameters during the 1995/96 dry season at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.907**	1.000										
3	0.783**	0.622**	1.000									
4	0.806**	0.781**	0.637**	1.000								
5	0.246**	0.325**	0.354**	0.002NS	1.000							
6	-0.077NS	-0.247**	-0.369**	0.338**	-0.500**	1.000						
7	-0.254**	-0.293**	-0.240**	-0.218**	-0.287**	-0.304**	1.000					
8	0.322**	0.033NS	-0.099NS	-0.016NS	-0.006NS	0.013NS	-0.339**	1.000				
9	0.340**	0.431**	0.204**	0.085NS	0.268**	-0.171*	-0.142NS	-0.436**	1.000			
10	-0.036NS	0.028NS	0.126NS	0.003NS	0.004NS	0.027NS	-0.164*	0.107NS	0.071NS	1.000		
11	0.276**	0.020NS	-0.044NS	0.229**	0.153NS	0.182*	-0.019NS	0.066NS	0.343**	0.262**	1.000	
12	0.213**	0.162*	0.106NS	0.093NS	-0.141NS	0.099NS	-0.211**	0.137NS	0.070NS	0.018NS	0.264**	1.000

1. Total fruit yield (t/ha) 2. Yield per plant (kg) 3. Average fruit weight (g) 4. Number of flowers/plant (7WAT)

5. Fruit firmness (^{0}0) 6. Percent soluble solids (%) 7. Days to 50% flowering 8. NAR (g/cm^{2}/wk) (6WAT) 9. LAI (9WAT)

10. Total dry matter (g) (9WAT) 11. Number of leaves/plant (9WAT) 12. Plant height (cm) (9WAT).

Table 89: The direct and indirect contributions of different growth characters on yield (t/ha) in 1995/96 dry seasons at Samaru.

Yield attributes	Effect through			
	Plant height (cm)	Number of Leaves	Total Dry matter	Total correlation with yield
Plantk height (cm)	0.209a	0.003	0.001	0.213
Number of leaves	0.055	0.014	0.007	0.076
Total dry matter (g)	0.004	0.003	0.029	0.036

(a) Direct effect underlined

Table 90: The direct and indirect contributions of different yield components on yield (t/ha) in 1995/96 dry seasons at Samaru.

Yield attributes	Effect through			
	Number of correlation Flowers	Average fruit weight(g)	Yield per Plant (kg)	Total with yield
Number of flowers	0.164a	0.186	0.456	0.806
Average fruit weight(g)	0.104	0.292	0.387	0.783
Yield per plant	0.128	0.194	0.585	0.907

(a) Direct effect underlined

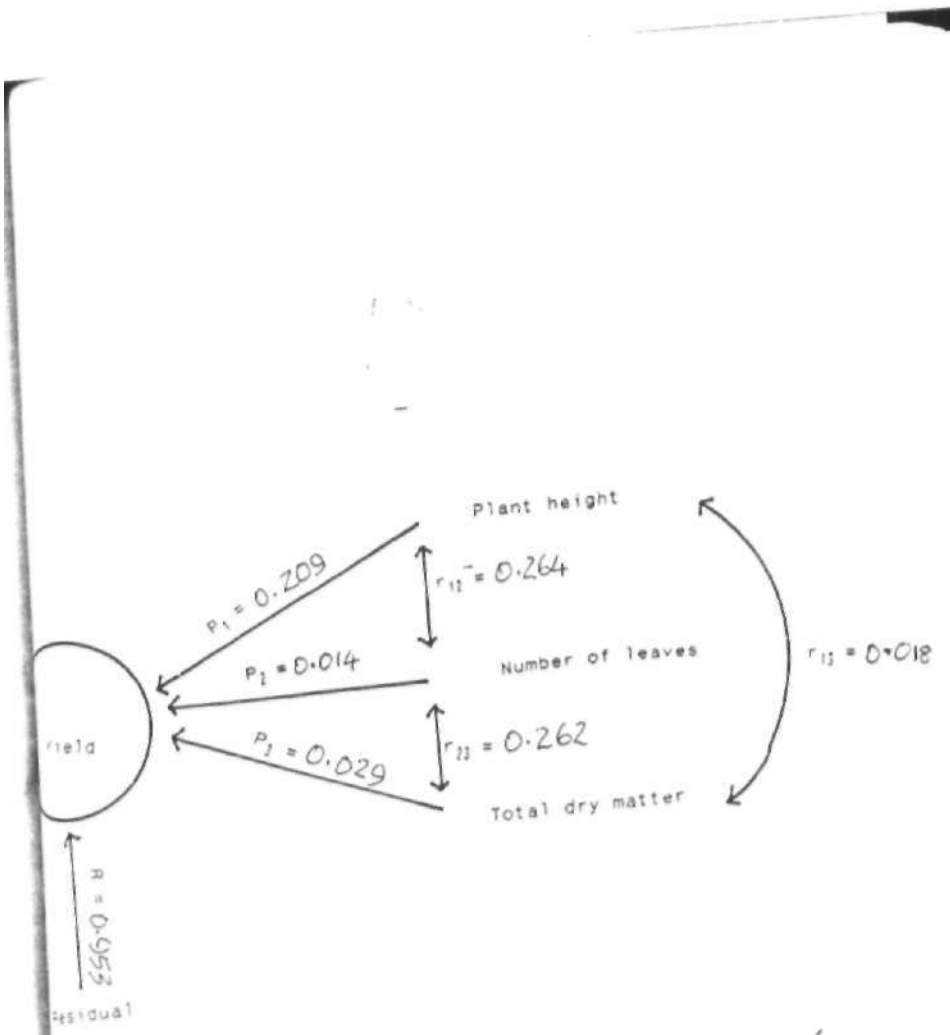


Fig. 5 Path diagram showing interrelations of total fruit yield (t/ha) and some growth characters in 1995/96 dry season at Samaru

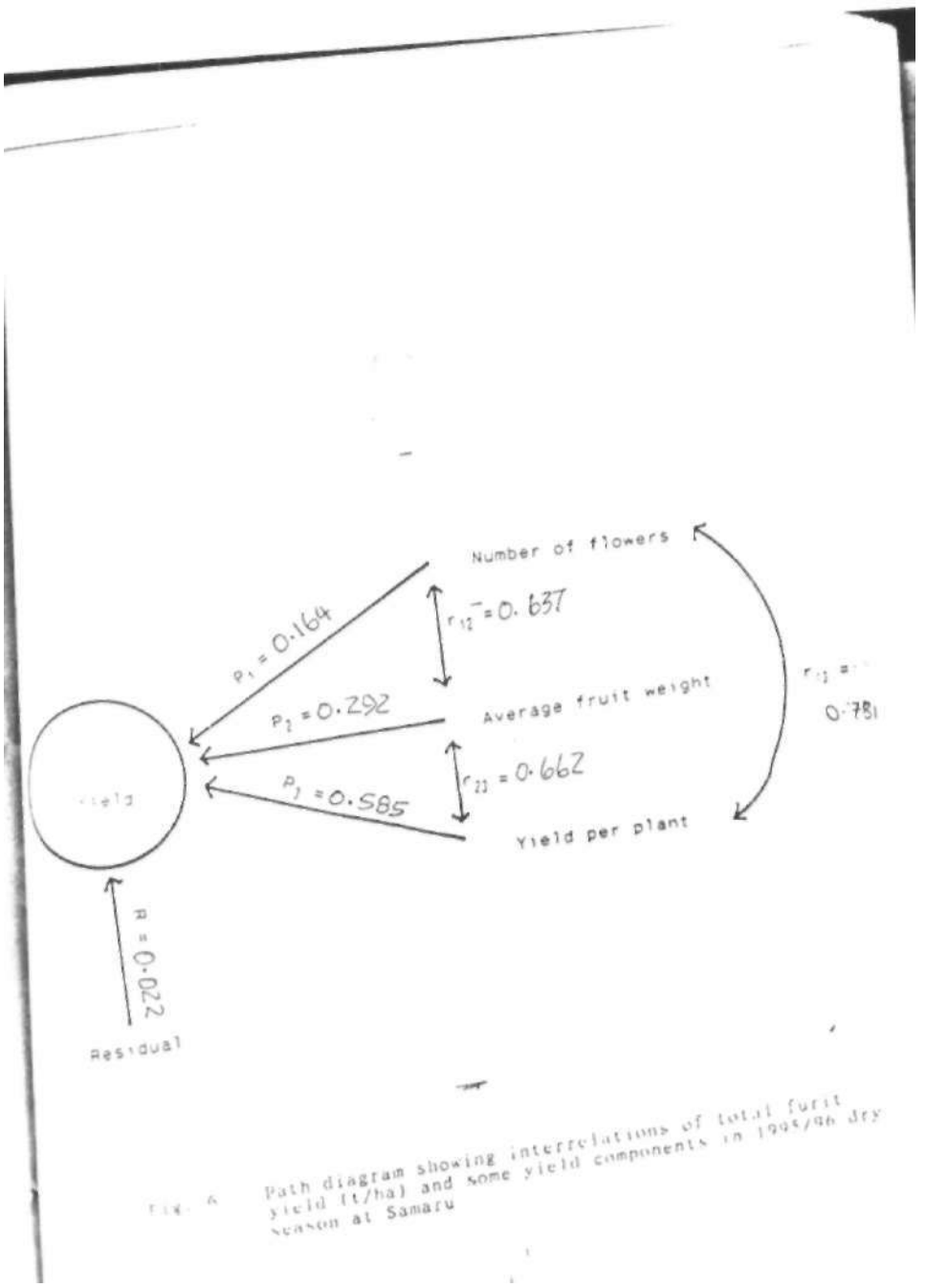


Fig. 6 Path diagram showing interrelations of total fruit yield (t/ha) and some yield components in 1995/96 dry season at Samaru

The percentage contributions of individual growth characters as well as their combined contributions to total fruit yield are presented in Table 91. Plant height made the highest individual contribution of 4.37% followed by total dry matter (0.08%) and number of leaves/plant had the least (0.02%). The highest combined contribution was made by plant height and number of leaves/plant (0.15%) followed by plant height and total dry matter and number of leaves and total dry matter each of which had 0.02%. The unaccounted residual effect was 95.34%.

The percentage contributions of individual yield characters as well as their combined contributions to total fruit yield of tomato are presented in Table 92. Yield/plant made the highest individual contribution of 34.3% followed by average fruit weight (8.47%) and number of flowers/plant (2.69%). The highest combined contribution was made by average fruit weight and yield/plant (22.5%), followed by number of flowers/planted and yield/plant (14.9%) and, lastly number of flowers/plant and average fruit weight (6.04%). A residual effect of 11.1% was unaccounted for in the analysis.

Table 91: The percentage contributions of different growth characters to total fruit yield (t/ha) in 1995/96 dry season at Samaru.

Yield attributes	Percent contributions (%)
Individual contributions	
Plant height (cm)	4.37
Number of leaves	0.02
Total dry matter(g)	0.08
Combined contributions	
Plant height and number of leaves	0.15
Plant height and total dry matter	0.02
Number of leaves and total dry matter	0.02
Residual	95.34
Total	100.0%

Table 92: The percentage contributions of different yield components to total fruit yield (t/ha) in 1995/96 dry season at Samaru.

Yield attributes	Percent contributions (%)
Individual contributions	
Number of flowers	2.69
Average fruit weight (g)	8.47
Yield per plant (kg)	34.3
Combined contributions	
Number of flowers and average fruit weight	6.04
Number of flowers and yield per plant	14.9
Average fruit weight and yield per plant	22.5
Residual	11.1
Total	100.0%

4.2.16 Correlation and Path Coefficient Analysis, 1996/97 dry season.

Correlation studies between total fruit yield of tomato and other plant parameters during the 1996/97 dry season are presented in Table 93. There was a very strong positive correlation at 1% level of significance between total fruit yield and yield/plant, average fruit weight, number of flowers/plant (7 WAT), leaf area index (9 WAT) and number of leaves per plant (9 WAT). Plant height and NAR were also positively and significantly correlated to total fruit yield but at 5% level of significance. Also a highly significantly negative correlation between days to 50% flowering and total fruit yield was observed at 1% level of significance. Considering correlation between the major yield components, it was observed that yield/plant was positively and highly significantly correlated to average fruit weight and number of flowers/plant (7 WAT). Average fruit weight was also positively and highly significantly correlated to number of flowers/plant (7 WAT).

The direct and indirect contributions of vegetative growth characters on total fruit yield are presented in Table 94 and the path coefficient diagram between total fruit yield and the vegetative growth characters is presented in Figure 7. They revealed that plant height contributed directly 13.4% to total fruit yield and indirectly, via number of leaves/plant and total dry matter 0.1% and 0.3%, respectively. Thus, total contribution by plant height to total fruit yield was 13.8%. When the

contribution of number of leaves/plant was examined, the direct effect was found to be 1.6% and the indirect effects, via plant height and total dry matter were 0.9% and -0.8%, respectively. Thus, the total contribution of number of leaves/plant to total fruit yield was 1.7%. When the total dry matter was investigated for its contribution to total fruit yield, the direct effect was found to be -3.9% and the indirect effects, via plant height and number of leaves/plant were -1.0% and 0.2%, respectively. Thus, the total contribution by total dry matter to total fruit yield was -4.7%.

The direct and indirect contributions of yield characters to total fruit yield of tomato is presented in Table 95 and the path coefficient diagram between total fruit yield and the yield characters is presented in Figure 8. The analyses revealed that number of flowers/plant directly contributed 4.7% to total fruit yield and indirectly, via average fruit weight and yield/plant contributed 6.0% and 78.6%, respectively. Thus the total contribution by number of flowers/plant to total fruit yield was 89.3%. When the contribution of average fruit weight to total fruit yield was examined, the direct effect was found to be 9.1% and the indirect effects, via number of flowers/plant and yield/plant were 3.1% and 68.2%, respectively. Thus the total contribution by average fruit weight to total fruit yield was found to be 80.4%. When the yield/plant was investigated for its contribution to total fruit yield the direct effect was observed to be 87.3% while the indirect effects, via number of flowers/plant and average fruit weight were 4.2% and 7.1%, respectively. Thus the total contribution by yield/ plant to

Table 93: Matrix of correlation coefficient between tomato fruit yield (t/ha) and various other plant parameters during the 1996/97 dry season at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.986**	1.000										
3	0.804**	0.781**	1.000									
4	0.893**	0.901**	0.654**	1.000								
5	0.124NS	0.075NS	0.007NS	0.462**	1.000							
6	-0.145NS	-0.187*	0.035NS	-0.239**	-0.618**	1.000						
7	-0.227**	-0.221**	-0.252**	-0.256**	-0.602**	-0.434**	1.000					
8	0.177*	0.029NS	0.038NS	-0.302**	-0.508**	0.253**	-0.428**	1.000				
9	0.374**	0.162*	0.058NS	0.328**	-0.444**	-0.167*	-0.138NS	-0.518**	1.000			
10	-0.047NS	-0.236**	0.134NS	0.002NS	0.004NS	0.031NS	-0.183*	0.121NS	0.089NS	1.000		
11	0.217**	0.021NS	-0.164*	0.232**	0.159*	-0.073NS	-0.008NS	-0.057NS	0.477**	0.189*	1.000	
12	0.158*	0.308**	0.046NS	-0.210**	-0.506**	0.419**	-0.460**	0.404**	-0.303**	-0.077NS	0.066NS	1.000

1. Total fruit yield (t/ha) 2. Yield per plant (kg) 3. Average fruit weight (g) 4. Number of flowers/plant (7WAT)
5. Fruit firmness (^{0}0) 6. Percent soluble solids (%) 7. Days to 50% flowering 8. NAR (g/cm^2/wk) (6WAT) 9. LAI (9WAT)
10. Total dry matter (g) (9WAT) 11. Number of leaves/plant (9WAT) 12. Plant height (cm) (9WAT).

Table 94: The direct and indirect contributions of different growth characters on yield (t/ha) in 1996/97 dry seasons at Samaru.

Yield attributes	Effect through			
	Plant height (cm)	Number of leaves	Total dry matter (g)	Total correlation with yield
Plant height (cm)	0.134a	0.001	0.003	0.138
Number of leaves	0.009	0.016	-0.008	0.017
Total dry matter (g)	0.010	0.002	-0.039	-0.047

(a) Direct effect underlined

Table 95: The direct and indirect contributions of different yield components on yield (t/ha) in 1996/97 dry season at Samaru.

Yield attributes	Effect through			
	Number of flowers	Average fruit weight (g)	Yield per Plant (kg)	Total correlation with yield
Number of flowers	0.047a	0.060	0.786	0.893
Average fruit weight (g)	0.031	0.091	0.682	0.804
Yield per plant (kg)	0.042	0.071	0.873	0.986

(a) Direct effect underlined

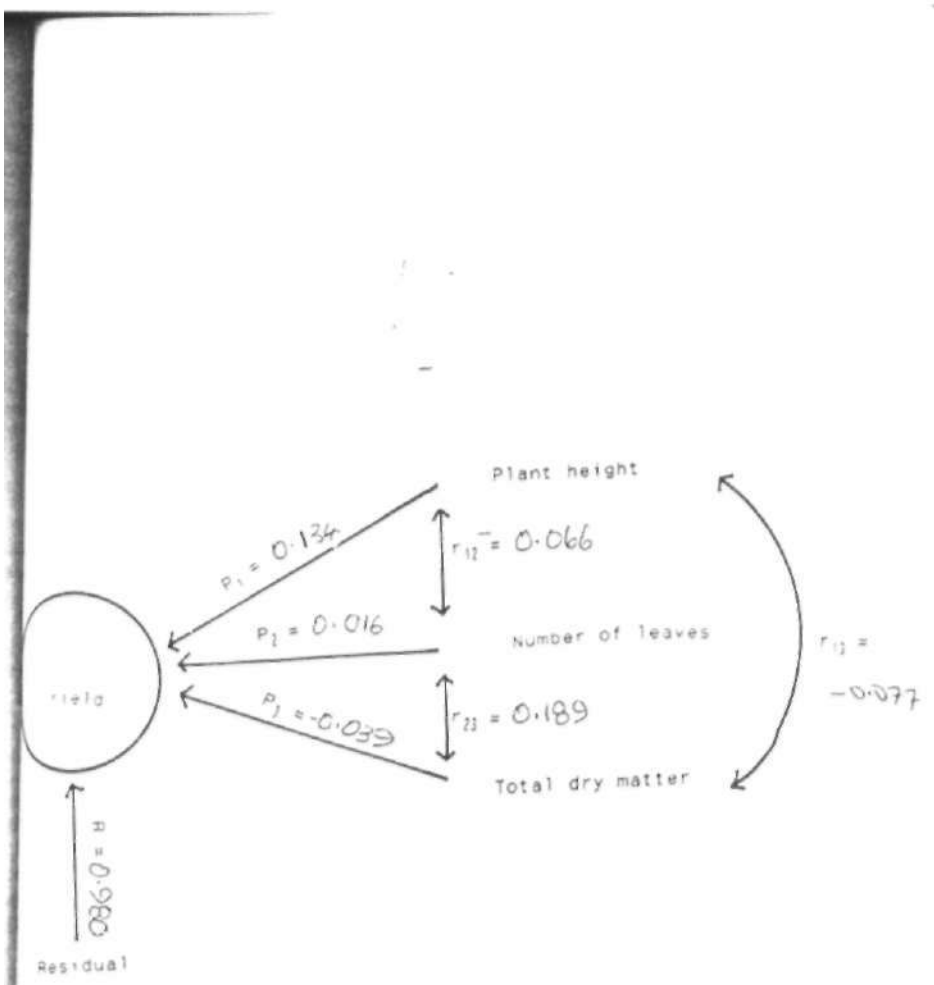


Fig. - Path diagram showing interrelations of total fruit yield (t/ha) and some growth characters in 1996/97 dry season at Samaru

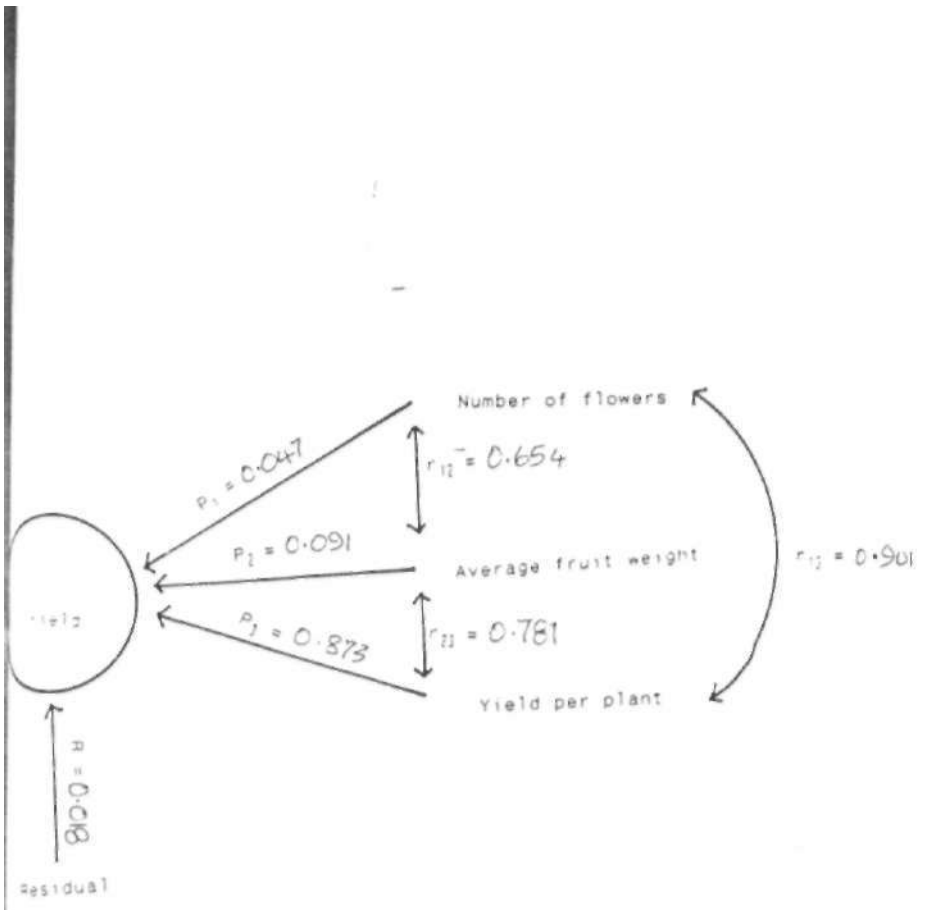


Fig. 8 Path diagram showing interrelations of total fruit yield (t/ha) and some yield components in 1996/97 dry season at Samaru

The percentage contributions of individual growth characters as well as their combined contributions to total fruit yield of tomato are presented in Table 96. Plant height made the highest individual contribution of 1.80% followed by total dry matter (0.15%) and number of leaves/plant had the least (0.03%). The highest combined contribution was made by plant height and total dry mater (0.07%) followed by plant height and number of leaves (0.03%) and lastly, number of leaves and total dry matter (0.02%). The unaccounted residual effect was 97.9%.

The percentage contributions of individual yield characters as well as their combined contributions to total fruit yield of tomato are presented in Table 97. Yield/plant made the highest individual contribution of 76.2% followed by average fruit weight (0.83%) and number of flowers/plant (0.22%). The highest combined contribution was made by average fruit weight and yield/plant (12.4%) followed by number of flowers/plant and yield per plant (7.38%) and lastly, number of flowers/plant average fruit weight (0.56%). A residual effect of 2.41% was unaccounted for in the analysis.

4.2.17 Polynomial response of total fruit yield to inter and intra-row spacing levels, 1995/96 and 1996/97 dry seasons.

Tables 98 and 99 show the deviations between observed and expected total fruit yields of tomato using the regression equations developed for both 1995/96 and 1996/97 dry seasons, respectively. It was observed that all deviations between observed and expected total fruit yields for both liner and quadratic regressions in both inter- and intra-row spacings for both dry seasons were not significant.

Table 96 The percentage contributions of different growth characters to total fruit yield (t/ha) in 1996/97 dry season at Samaru.

Yield attributes	Percent contribution
Individual contributions	
Plant height (cm)	1.80
Number of leaves	0.03
Total dry matter (g)	0.15
Combined contributions	
Plant height and number of leaves	0.03
Plant height and total dry matter	0.07
Number of leaves and total dry matter	0.02
Residual	97.9
Total	100.0%

Table 97: The percentage contributions of different yield components to total fruit yield (t/ha) in 1996/97 dry season at Samaru.

Yield attributes	Percent contributions (%)
Individual contributions	
Number of flowers	0.22
Average fruit weight (g)	0.83
Yield per plant (kg)	76.2
Combined contributions	
Number of flowers and Average fruit weight	0.56
Number of flowers and yield per plant	7.38
Average fruit weight and yield per plant	12.4
Residual	2.41
Total	100.0%

Table 98: Polynomial response of total fruit yield (t/ha) to inter- and intra-row spacings in 1995/96 dry season at Samaru.

Treatment	Linear 0	E	X^2	Quadratic E	X^2
Inter-row spacing (cm)					
45	34.5	33.3	0.043	30.0	0.444
60	31.2	30.4	0.021	30.1	0.040
75	27.1	27.4	0.003	29.2	0.151
			ΣX^2 0.067NS		ΣX^2 0.635NS
Intra-row spacing (cm)					
30	34.4	34.8	0.005	29.4	0.850
45	30.6	30.1	0.008	28.5	0.155
60	26.2	26.0	0.002	27.0	0.023
			ΣX^2 0.015NS		ΣX^2 1.028NS

Regression equations:

Inter-row spacing YL = 42.2 - 0.1971X

YQ = 31.5 + 0.0067307X - 0.0005066X^2

Intra-row spacing YL = 43.5 - 0.2914X

YQ = 30.1 + 0.0073573X - 0.0009709X^2

0 = Observed value
E_2 = Expected value
X^2 = Chi-square value
NS = Not significant

Table 99: Polynomial response of total fruit yield (t/ha) to inter- and intra-row spacings in 1996/97 dry season at Samaru.

Treatment	Linear			Quadratic	
	0	E	X^2	E	X^2
Inter-row spacings(cm)					
45	43.1	45.6	0.137	60.2	4.857
60	61.4	56.9	0.356	62.2	0.010
75	65.6	68.2	0.099	63.6	0.063
			ΣX^2 0.592NS		ΣX^2 4.930NS
Intra-row spacings (cm)					
30	47.5	50.4	0.167	60.6	2.832
45	59.8	56.7	0.169	61.8	0.065
60	61.4	62.9	0.036	62.6	0.023
			ΣX^2 0.372NS		ΣX^2 2.920NS

Regression equations:

Inter-row spacing YL = 102 - 0.752 x; YQ = 65.4+ - 0.0050206 x - 0.0009785x^2

Intra-row spacing YL = 75.4 - 0.0416x YQ -37.0 + 1.43 x 0.0205x^2

0 = Observed value
E = Expected value
X^2 = Chi-square value
NS = Not significant

4.3 Combined analysis.

4.3.1 Average fruit weight, combined.

Table 100 shows the effect of the various treatments (including season) on the average fruit weight of tomato. Average weight of fruits during the 1995/96 dry season was observed to be significantly higher than those of 1995 wet season, 1996 wet season and 1996/97 dry season which were at par and had similar average fruit weights. TI 468 recorded significantly higher average fruit weight than TI 539 which in turn, also had significantly higher average fruit weight than TI 106 and 182, which were at par with each other. Both inter- and intra-row spacings had no significant effect on average fruit weight.

Interaction effect between season and variety on average fruit weight was observed to be significant (Table 101). 1996 wet season x TI 468 had the highest average weight of fruit and 1996 wet season x TI 182 recorded the least average fruit weight. In general, TI 182 had the least average fruit weight in all seasons. All other interactions on average fruit weight were not significant.

4.3.2 Yield per plant, combined.

1996/97 dry season recorded significantly the highest tomato fruit yield/plant followed by all the other seasons (1995 and 1996 wet seasons and 1995/96 dry season) which were similar and at par with each other (Table 100). TI 539 and 106 were observed to have similar and significantly higher fruit yield/plant than

TI 182 which, in turn, also had significantly higher fruit yield/plant than TI 468.

The two higher inter- and intra-row spacing levels (75 and 60cm and 60 and 45cm, respectively) recorded similar and significantly higher fruit yield/plant than the two lower levels of 45 and 30cm, respectively.

All interaction effects on fruit yield/plant were not significant.

4.3.3 Total fruit yield, combined.

Total fruit yield during the 1996/97 dry season was observed to be significantly higher than those of 1995 wet, 1996 wet and 1995/96 dry seasons which were at par with each other and had similar total fruit yield (Table 100). Variety TI 539 recorded significantly the highest total fruit yield than TI 106 and 182, which were at par with each other and also recorded significantly higher total fruit yield than TI 468.

The 45 and 60cm inter-row spacings resulted in statistically higher fruit yield per hectare than the 75cm spacing.

Similarly, the 30 and 45cm intra-row spacings also recorded statistically higher total fruit yield of tomato than the 60cm spacing.

The interaction between inter-row spacing and variety showed that the highest yield was recorded by 45cm x TI 539 and the lowest yield by 45cm x TI 468 (Table 102). For TI 539, the closer the inter-row spacing, the higher the yield but for TI 468 it was vice varsa. TI 106 and 182 performed better at 60 and

45cm inter-row spacing. The interaction between intra-row spacing and variety showed that the highest total fruit yield was recorded by 30cm x TI 539 and the lowest by 30cm x TI 468 (Table 103). For TI 539, 106 and 182 the closer the intra-row spacing, the higher the yield. TI 468 yields better under the two higher intra-row spacings of 45 and 60cm. The interaction between season and tomato varieties revealed that the highest yield was recorded by 1996/97 dry season x TI 539 and the least by 1996 wet season x TI 468 (Table 104) TI 539 appeared to have performed better than all the other varieties in all the seasons followed by TI 106 and 182 which also appeared to have performed better than TI 468. In general all the varieties performed better during the dry seasons than during the wet seasons.

Table 100. Effects of inter and intra-row spacings on average fruit weight, yield/plant and total fruit yield (t/ha), (Combined analysis for the four seasons) of four tomato varieties at Samaru.

Treatments	Average fruit weight (g)	Yield/plant (kg)	Total fruit yield (t/ha)
Seasons			
1995	40.1b	0.47b	24.6b
1996	41.2b	0.74b	22.1b
1995/96	44.6a	0.62b	30.5b
1996/97	38.8b	1.03a	56.8a
SE ±	1.11	0.09	4.56
Varieties			
TI 106	39.2c	0.77a	34.1b
TI 182	39.2c	0.70b	33.1b
TI 468	45.3a	0.62c	27.6c
TI 539	51.8b	0.78a	39.5a
SE ±	0.57	0.02	1.03
Inter-row spacings (cm)			
45	40.6	0.66b	38.1a
60	41.5	0.73a	34.9a
75	42.1	0.76a	28.5b
SE ±	0.53	0.02	1.16
Inter-row spacings (cm)			
30	41.0	0.60b	37.5a
45	41.5	0.77a	34.4a
60	41.6	0.78a	29.7b
SE ±	0.53	0.02	1.16
Interactions			
I x i	NS	NS	NS
I x v	NS	NS	*
i x V	NS	NS	*
S x I	NS	NS	NS
S x i	NS	NS	NS
S x V	*	NS	*
I x i x V	NS	NS	NS
S x I x i	NS	NS	NS
S x I x V	NS	NS	NS
S x i x V	NS	NS	NS
S x I x i x V	NS	NS	NS

Means in column of any set of treatment followed by unlike letter(s) are significantly different at 5% abd 1% level of significance using DMRT.

* and ** = significant at 5% and 1% levels of significance respectively.
NS = Not significant. I and iI inter and intra-row spacings, respectively
V = Varieties. S = Seasons.

Table 101: Interaction of season x variety on average fruit weight (g) of tomato (combined analysis).

Treatment	Season			
	1995 wet season	1996 wet season	1995/96 dry season	1996/97 dry season
Variety				
TI 106	42.0cd	38.1ef	44.6bc	38.1ef
TI 182	39.8def	35.4f	36.6f	36.9f
TI 468	42.7cd	52.4a	46.5b	39.7df
TI 539	41.7cd	42.2cd	42.8cd	40.4de
SE ±	1.13			

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 102: Interaction of inter-row spacing x variety on total fruit yield (t/ha) of tomato (combined analysis).

Treatments	Inter-row spacing (cm)		
	45	60	75
Variety			
TI 106	38.7b	33.2cd	30.3de
TI 182	35.0bcd	35.6bcd	28.8e
TI 468	23.0f	29.7de	30.0de
TI 539	29.6a	38.0bc	31.1de
SE ±	1.78		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 103: Interaction of intra-row spacing x variety on total fruit yield (t/ha) of tomato (combined analysis).

Treatments	Intra-row spacing (cm) 30	45	60
Variety			
TI 106	37.6bc	33.5cd	31.1d
TI 182	40.4b	31.1de	27.8ef
TI 468	20.2g	30.5def	26.6ef
TI 539	46.3a	39.2b	33.1c
SE ±	1.78		

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 104: Interaction of season x variety on total fruit yield (t/ha) of tomato (combined analysis).

Treatment	Season 1995 wet season	1996 wet season	1995/97 dry season	1996/97 dry season.
Variety				
TI 106	25.3ef	23.5efg	32.5cd	55.0b
TI 182	22.5fg	22.3fg	35.4c	53.2b
TI 468	17.2g	17,9g	19.6fg	49.7b
TI 539	28.2de	26.3ef	34.5c	69.2a
SE ±	2.06			

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.3.4 Correlation and Path Coefficient Analysis. (Combined Analysis 4 Seasons).

Correlation studies between total fruit yield and yield characters (components) for the combined analysis of the four seasons are presented in Table 105. There was a very strong positive correlation at 1% level of significance between total fruit yield and yield/plant, average fruit weight and number of flowers/plant (7 WAT). Considering correlation between the yield components, it was observed that yield/plant was also positively correlated to average fruit weight and number of flowers/plant (7 WAT) at 1% level of significance. Also at 1% level, average fruit weight was strongly and positively correlated to number of flowers/plant (7WAT).

The direct and indirect contributions of yield characters on total fruit yield of tomato is presented in Table 106 and the path coefficient diagram between total fruit yield and the yield characters is presented in Figure 9. The analyses revealed that number of flowers/plant directly contributed 13.3% to total fruit yield and indirectly, via average fruit weight and yield/plant 8.8% and 49.0%, respectively. Thus, the total contribution by number of flowers/plant to total fruit yield was 71.1%. When the contribution of average fruit weight to total fruit yield was examined the direct effect was found to be 20.9% and the indirect effects, via number of flowers/plant and yield/plant were 5.6% and 37.6%, respectively. Thus, the total contribution by average fruit weight to total fruit yield was found to be 64.1%. When the yield/plant was investigated for its contribution to total

fruit yield the direct effect was observed to be 69.6% while the indirect effects, via number of flowers/plant and average fruit weight were 9.2% and 11.0%, respectively. Thus, the total contribution by yield/plant to total fruit yield was 89.8%.

The percentage contributions of individual yield components (characters) as well as their combined contributions to total fruit yield of tomato are presented in Table 107. Yield/plant made the highest individual contribution of 48.4% followed by average fruit weight (4.37%) and number of flowers/plant (1.77%) which had the least. The highest combined contribution was made by average fruit weight and yield/plant (15.7%) followed by number of flowers/plant and yield/plant (13.0%) and lastly, number of flowers/plant and average fruit weight (2.36%). A residual effect of 14.4% was unaccounted for in the analysis.

4.3.5 Polynomial response of total fruit yield to inter and intra-row spacing levels, combined analysis.

Results of polynomial response for all the four seasons combined are presented in Table 108. Deviations from both linear and quadratic regressions between observed and expected total fruit yields of tomato were not significant at all the inter-row spacing levels as well as the intra-row spacing levels.

Table 105: Matrix of correlation coefficient between tomato fruit yield (t/ha) and yield characters. (Combined analysis) at Samaru.

	1	2	3	4
1	1.000			
2	0.898**	1.000		
3	0.641**	0.541**	1.000	
4	0.711**	0.704**	0.419**	1.000

1. Total fruit yield (t/ha)
2. Yield/plant (kg)
3. Average fruit weight (g)
4. No. of flowers/plant (7 WAT)

** = Significant at 1% level of significance

Table 106: The direct and indirect contributions of different yield components on yield (t/ha) (Combined analysis) at Samaru.

Yield attributes	Number of flower	Effect through Average fruit weight (g)	Yield per plant (Kg)	Total correlation with yield
Number of flowers	0.133(a)	0.088	0.490	0.711
Average fruit weight (g)	0.056	0.209	0.376	0.641
Yield per plant (kg)	0.092	0.110	0.696	0.898

(a), Direct effect underlined.

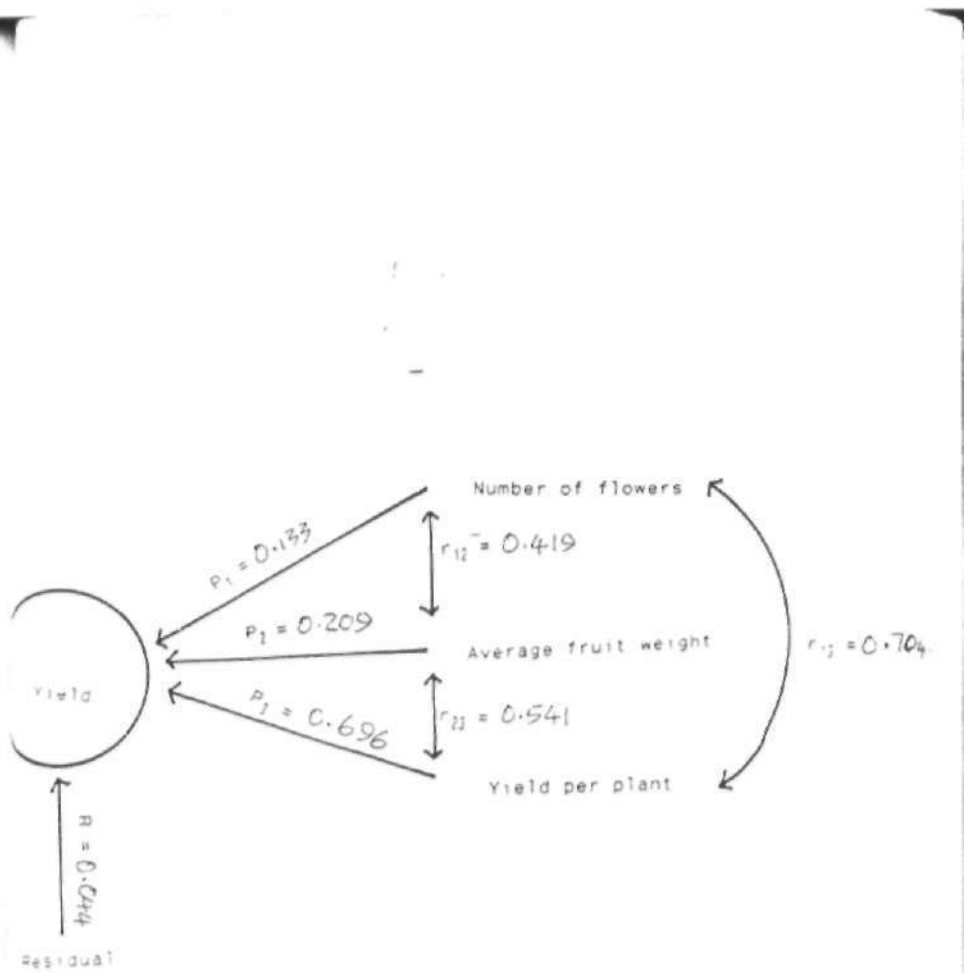


Fig. 9 Path diagram showing interrelations of total furit yield (t/ha) and some yield components (combined analysis) at Samaru

Table 107: The percentage contributions of different yield components to total fruit yield (t/ha) (combined analysis) at Samaru.

Yield attributes	Percent contributions (%)
Individual contributions	
Number of flowers	1.77
Average fruit weight (g)	4.37
Yield per plant (kg)	48.4
Combined contributions	
Number of flowers and Average fruit weight	2.36
Number of flowers and yield per plant	13.0
Average fruit weight and yield per plant	15.7
Residual	14.4
Total	100.0%

Table 108: Polynomial response of total fruit yield (t/ha) to intra and intra-row spacings (Combined analysis) at Samaru.

Treatment	Linear			Quadratic	
	0	E	X^2	E	X^2
Inter-row spacings(cm)					
45	38.1	38.4	0.002	38.0	0.0003
60	34.9	33.6	0.050	34.1	0.0190
75	28.5	28.8	0.003	28.4	0.0004
			ΣX^2 0.055NS		ΣX^2 0.0197NS
Intra-row spacings (cm)					
30	37.5	38.5	0.026	37.5	0.000
45	34.4	34.6	0.001	33.5	0.024
60	29.7	30.7	0.033	29.6	0.003
			ΣX^2 0.060NS		ΣX^2 0.027NS

Regression equations:

Inter-row spacing YL = 52.8 - 0.32046x; YQ = 39.1+ - 0.1547448x - 0.003960x^2
Intra-row spacing YL = 46.4 - 0.26176X; YQ 45.4 - 0.26588 +000045x^2

0 = Observed value
E = Expected value
X^2 = Chi-square value
NS = Not significant

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of Seasons.

The vegetative growth performance of tomato, as evidenced by such parameters as plant height and total dry matter was much higher in the wet seasons than in the dry seasons of the trial. Plants were more taller and accumulated higher dry matter content as a result of more vigourous growth during the wet seasons (which were warmer) than during the dry seasons (which are cold during their early periods/stages). All vegetable crops grown during the dry seasons tend to grow very slowly in their initial periods because of the cold weather between the months of October to December (Quinn 1980, Amans *et al*, 1986). Number of leaves and leaf area index (LAI) were observed to be higher during the dry seasons than during the wet seasons of the trials. Although the crop tends to grow more profusely in the wet seasons than in the dry seasons, high incidence of pests and diseases problems during the wet seasons than during the dry seasons tends to limit the number of leaves (and as such lower LAI) during the wet seasons than during the dry season conditions, which usually has very limited pest and disease problems. No seasonal differences in terms of relative growth rate (RGR) and net assimilation rate (NAR) were observed in the dry and wet seasons of the trial. This showed that these parameters were not affected by any seasonal differences. It had been reported that irrespective of the season the rate of crop growth tends to decline already even

before crops are transplanted to the field (Blackman, 1919).

The number of flowers per plant was observed to be the same for 3 seasons of the trial and the only exception was 1996/67 dry season. Here, the plants recorded higher number of flowers per plant than the 2 wet (1995 and 1996) seasons and 1 dry (1995/96) season. Fruit firmness was similar for 3 seasons, with the exception of 1995/96 dry season. The fruits were more firm in 1995 and 1996 wet seasons and 1996/97 dry season than in 1995/96 dry season. This could be attributed to the fact that during the harvesting period of the 1995/96 dry season was significantly hotter than during the other two wet seasons and one dry season and as such the fruits were softer than the fruits of the other 3 seasons (Appendix III). Percent soluble solids was not affected by any seasonal variation in all trials conducted. This is an indication that regardless of the season the crop is planted the percent soluble solids of the fruits will remain the same. Average fruit weight was, however, affected by the seasonal differences, with fruits produced during the wet seasons being significantly heavier than fruits produced during the dry seasons. This is an indication that during the wet seasons, because water is more readily available to the crop, and the environment is not as such dry, the fruits tend to accumulate or collate as much water content as they want than during the dry seasons, whereby water has be applied to the crops through irrigation. During the dry season there is greater evaporation and transpiration and as such the crops had to compete for water

with the environment and it may not likely get the optimum it (the crop) needs for its optimum growth and yield. Yield/plant and total fruit yield were more in the dry seasons than in the wet seasons of the trials. This is due to the fact that tomato suffers greater pests and diseases problems during the wet seasons which limits its yielding ability than during the wet seasons (Quinn, 1980; Amans, 1988).

5.2 Effect of Variety.

Significant differences in growth characters were observed during the 4 seasons of the trials. Variety TI 468 was observed to be clearly the tallest in all seasons followed by TI 106 and TI 182, with TI 539 being the shortest of all in all 4 seasons of the trial. TI 468 also recorded the highest total dry matter (TDM) and highest relative growth rate (RGR) in all 4 seasons of the study. Number of leaves/plant during the 1995/96 dry season was also highest in TI 468 than the other 3 varieties. Ibrahim (1996) described TI 468 as an indeterminate variety with more profuse, vegetative growth than TI 106 (semi-determinate) and TI 539 (determinate). TI 182 was also observed to be a semi-determinate variety from the study. Net assimilation rate (NAR) was observed to be highest in variety TI 106 followed by TI 182 and TI 468, and least in TI 539. Variety TI 106 and TI 539 had the highest leaf area index (LAI) followed by TI 182 and TI 468 in all 4 seasons of the trial, which confirmed their having higher number of leaves per plant in the 1995, 1996 and 1996/97 trials. Despite TI 468 having the highest number of leaves in

1995/96 it recorded a lower LAI than the others 3 varieties. This was due to relatively smaller leaf sizes in TI 468 than in the other 3 varieties.

Flowering was earlier and more prolific in TI 106 and TI 539 than in TI 182, with TI 468 recording the least number of flowers/plant in all four seasons of the trials. This is probably because TI 106 and TI 182 (semi-determinate) and TI 539 (determinate) stopped their vegetative growth at a certain time of the crop growth period to continue with their reproductive growth while TI 468 (indeterminate) combined its vegetative as well as reproductive growth which, in turn, will result in sharing its nutrients both ways. Significant varietal differences in terms of number of days to 50% flowering and days to first harvest were observed among the tomato varieties but only during the dry seasons of the trials, with TI 106 attaining days to 50% flowering as well as days to first harvest much earlier than TI 182, TI 468 and TI 539 which were at par with each other. The flowering stage of tomato is genetic and represents the most critical stage of its development (Kuo *et al*, 1979). The more conducive environmental factors for crop growth during the wet seasons may have resulted in the varieties to have flowered at the same time than during the cooler dry seasons whereby the varieties will express their full genetic potentials. Fruits of varieties TI 539, TI 106 and TI 182 were observed to be more firm than those of variety TI 468 in all 4 seasons of the trial. This is due to the fact that TI 468 has more water

content in it and more soft than the other three varieties that are more fleshy and had less water content in their fruits. Percent soluble solids of TI 468 was higher than those of varieties TI 106, TI 182 and TI 539. This could be due the fact that TI 468 has more water content and is also a round and soft fleshy tomato fruit with higher juice content (Ibrahim, 1996). than the other 3 varieties. In 4 seasons of the trials varieties TI 468 and TI 539 had higher average fruit weights followed by TI 106 while TI 182 recorded the least average fruit weight. This could be attributed to the fact that these 3 varieties (TI 468, TI 539 and TI 106) are bigger tomatoes in terms of fruit size than TI 182. Another factor may be in the genetic make up of the tomato plants. Yield/plant was observed to be highest in varieties TI 106 and TI 539 followed by TI 182 with TI 468 recording least yield/plant in all 4 seasons. Similarly, total fruit yield (t/ha) was observed to be highest in TI 539 and 106 followed by TI 182, with also here, TI 468 having the least total fruit yield (t/ha) in all 4 seasons of the trials. This could be attributed to the fact that the 3 varieties are semi-determinates (TI 106 and TI 182) and determinate (TI 539) and as such diverted most of their nutrient flow to their reproductive growths (in this case fruits), unlike TI 468 which is an indeterminate variety whose nature is such that vegetative growth does not terminate at the on set of reproductive growth and has to share its nutrient flow both ways.

5.3 Effect of Inter-row spacing.

The increase in plant height with decrease in inter-row spacing in 1995/96 dry season could be ascribed to competition among plants for light as the plants have to grow taller to get solar radiation. Similar results were reported by Yakovenko (1978). The production of leaves and total dry matter (TDM) were depressed with decreases in inter-row spacing. These results are in accordance with the findings of Topoleski (1967) who regarded competition between plants for water and nutrients to be the main cause of reduced growth in dense canopies of plants. LAI was observed to be higher at closer inter-row spacings and this is due to the presence of more plants per area and hence more leaves per unit area. Nichiporovich (1960) suggested that an optimal leaf area index is definable for every economic crop and also went on to state that maximum LAI does not always yield maximum dry matter production. Both RGR and NAR were increased with decreases in inter-row spacing. Donald (1961) has held that closer plant stands, initially have more rapid growth, because they display more photosynthetic surface per unit area of ground and synthesize more material.

Number of flowers per plant was not significantly affected by variations in inter-row spacing in this study. This could mean that the spacing levels in this trial were not so different enough as to affect the flower number produced by the plants. This result is in agreement with the findings of Seno and Kimoto (1989). Days to 50% flowering and days to first harvest were also not significantly affected by the spacing levels considered

but only in the 2 wet season trials (1995 and 1996). However in 1995/96 and 1996/97 dry seasons these parameters were attained much earlier at the wider inter-row spacing levels of 75 and 60cm. This could mean that at these spacing levels the plants grow normally and were not subjected to any competition or stress during their growth period as to cause a delay in them reaching their reproductive growth period early enough. Fruit firmness was also not significantly affected by the inter-row spacing levels during the 2 wet seasons and 1995/96 dry season trials. However, during the 1996/97 dry season trial the tomato fruits were more firm at wider inter-row spacing levels of 75 and 60cm. This could be due to the fact that the temperature during this period of the trial has started getting more warmer and the tomato fruits on plants spaced at close inter-row spacing of 45cm are becoming more soft as a result of increase in heat generated from the plants that were so closely transplanted at this close spacing when compared with the plants spaced at 75 and 60cm which were more airy (Appendix IV). The percent soluble solids and average fruit weight were also not significantly affected by the variation in the inter-row spacing levels at all 4 seasons of the trial. This could also mean that the spacing levels considered here were not so variable enough as to affect these parameters. Yield/plant was observed to be higher at wider inter-row spacings of 75 and 60cm in all 4 seasons of the trial. This could be attributed to the more availability of nutrients, water and light to plants under lower densities. This result is in agreement

with the findings of Postiglione and Lanza (1978) and Seno and Kimoto (1989).

In spite of the fact that yield/plant was higher at wider inter-row spacings, total fruit yield per hectare was significantly higher at closer inter-row spacing in all 4 seasons of the trial. This could be due to the fact that increase in plant number more than compensated for the decrease in productivity per plant at wider spacings. This result is in agreement with the findings of Yakovenko (1978), Postiglione and Lanzo (1978), Joshi *et al.* (1989) and several other workers.

5.4 Effect of Intra-row Spacing.

As in the case of inter-row spacing, plant height was also observed to be higher at closer intra-row spacing in 1995/96 dry season. This is also in agreement with the findings of Yakovenko (1978). Number of leaves per plant and TDM were also higher at wider intra-row spacings. This result is in agreement with the findings of Adelana (1976). The competition for light, water and nutrient in plants that are spaced so closely could be the cause of reduced leaf number per plant and total dry matter accumulation in dense canopies of plants (Blackman, 1919 and Topoleski, 1967). LAI was observed to be higher at closer intra-row spacing and this is also due to the presence of more plants per unit area and hence more leaves per unit area. Both RGR and NAR were higher at closer intra-row spacings. This is also in agreement with the findings of Donald (1961). The increase in NAR with decrease in intra-row spacing could also be related to

LAI (Watson, 1958).

Number of flowers per plant was significantly affected by the intra-row spacing levels but only in the 2 wet seasons of the trial. Number of flower per plant was observed to be more at wider intra-row spacings than at closer intra-row spacings. This could mean that at closer intra-row spacings there was heavy over crowding and the flowers were not formed in large number per plant than they were formed in widely spaced plants. During the 2 dry seasons of the trials days to 50% flowering and days to first harvest were attained much earlier in plants with wider intra-row spacing than those with closer intra-row spacing. This could mean that here the plants were growing at a normal phase and therefore were not subjected to any competition or stress as to cause them to flower and fruit earlier than their normal flowering and fruiting period. This result is in disagreement with the findings Moldoveanu (1977) who reported that earlirness was enhanced in 2 tomato cultivars at the closest intra-row spacing of 15cm but not at 30cm. No significant difference in fruit firmness was observed during the 2 wet seasons of the trial. However, during the 2 dry seasons of the trial, fruits were observed to be more firm at wider intra-row spacings of 60 and 45cm. This could also be due to the fact that temperature during the harvesting period has started getting more warmer and the fruit on plants that were closely spaced at intra-row spacing of 30cm are becoming more softer than their counter parts at 60 and 45cm intra-row spacing as a result of the increase in heat

generated from the plants that were so closely transplanted at this close spacing of 30cm (Appendices III and IV). Percent soluble solids was observed to be higher in plants closely spaced at intra-row spacing of 30cm in 1995 wet and 1996/97 dry seasons. This could mean that the fruits from the closely spaced plants are shaded very well by their dense leaf canopy from the solar radiation which may have an effect in altering the chemical composition of the fruit than their counterparts spaced at wider intra-row spacings of 60 and 45cm. Average fruit weight, like in inter-row spacing was also not significantly affected by the variation in intra-row spacing levels. This could also mean that the intra-row spacing levels considered in this trial were not variable enough as to affect it. Yield/plant was also observed to be higher at wider intra-row spacings of 60 and 45cm in all 4 seasons of the trial. This could also be attributed to the more availability of nutrients, water and light to plants transplanted at wider intra-row spacings. This result is agreement with the findings of Amans (1988) and Dimri and Gulshan (1988).

Despite the fact that yield/plant was higher at wider intra-row spacings, it was however, observed that total fruit yield per hectare was significantly higher at closer intra-row spacing in all 4 seasons of the trial. This could also be due to the fact that increase in plant number per unit area more than compensated for the decrease in yield per plant at wider intra-row spacings. Higher yield per hectare could also be attributed to higher LAI; because closer intra-row spacings display more photosynthetic

surface per unit area of ground, they synthesize more assimilates (Donald, 1961). This result is also in consonant with the findings of Amans (1988), Adelana (1976), Moldoneavu (1977), Bhatnagar and Pandita (1979) and several other workers.

5.5 Interactions.

5.5.1 Inter-row x Intra-row spacings interactions.

The highest number of leaves obtained in 1996 at 3 WAT and the highest LAI at 3WAT in 1995/96 with the closest inter- and intra-row spacings of 45 x 30cm are in agreement with the findings of Joshi *et al* (1980) who reported obtaining the highest LAI at the closest spacings of 30 x 30cm. TDM was observed to be higher at the wider spacings of 75 x 60cm at 6 WAT in 1995/96 dry season and this seem to support the findings of Rodriguez and Frutos (1976) and Joshi *et al* (1980) who reported obtaining the highest total dry matter at the widest spacings of 150 x 30cm and 60 x 60cm than at the closest spacings of 150 x 15cm and 30 x 30cm, respectively.

The highest total fruit yield per hectare obtained at the closest spacings of 60 x 45cm in 1995, 1996 and 1995/96 trials and at 45 x 30cm in 1996/97 trial seem to support the findings of several workers who reported obtaining higher total fruit yields per hectare at closer inter- and intra-row spacings than at wider spacings (Lopez and Chang, 1974; Rodriguez and Frutos, 1976; Rastogi *et al*, 1978; Hassan, 1978; Joshi *et al*, 1980).

5.5.2 Inter-row spacing x variety interactions.

The highest LAI obtained by all the tomato varieties at the closest inter-row spacing of 45cm in 1995/96 dry season is an indication that irrespective of the variety used LAI will always be higher at the closest spacing used because of the higher number of plants per unit area.

All the tomato fruits of all the varieties tested were observed to be more firm at the widest spacing of 75cm and more softer at the closest inter-row spacing of 45cm in 1996/97. This could mean that at a denser situation of plant growth the heat generated by the environment and the plant itself may have made the fruits to be a bit softer than when the plants are more widely spaced whereby air circulation is more and the temperature is less high.

The yields of the tomato varieties varied significantly in their response to inter-row spacing. TI 106 and TI 182 yielded better at 45 - 60cm spacing; with TI 468 at 75cm and TI 539 at 45cm inter-row spacing. This is an indication that TI 106 and TI 182, semi-determinate varieties can perform better at the medium spacing considered here (60cm); TI 468 which is an indeterminate variety needs wider inter-row spacing for it to express its full growth and yield potential; while TI 539, which is a determinate more compact variety does best at the closest inter-row spacing of 45cm.

5.5.3 Intra-row spacing x variety interaction.

Number of leaves per plant was highest in varieties TI 106, TI 182 and TI 539 at the closest intra-row spacing of 30cm while in variety TI 468 it was highest at the widest intra-row spacing of 60cm in 1996 at 9 WAT. The 3 varieties are semi-determinates (TI 106 and TI 182) and determinate (TI 539) while TI 468 is indeterminate. This could mean that the 3 varieties could produce their optimum leaf number at 30cm comfortably without any deterrent to their growth while the other variety (TI 468), an indeterminate cultivar in its growth habit, will need a more wider intra-row spacing above 30cm (in this case 60cm) to express its full growth potential. The highest TDM recorded in 1995/96 at 6 WAT by TI 106,TI 182 and TI 468 (semi-determinate and indeterminate respectively) at widest intra-row spacing of 60cm and by TI 539 (determinate) at 45cm means that TI 106 TI 182 and TI 468 will need a more wider intra-row spacing than TI 539 for them to attain their optimum vegetative growth with respect to TDM. The highest LAI obtained by all the tomato varieties at the closest intra-row spacing of 30cm in 1995 (3 and 9 WAT) and 1995/96 (3 WAT) is also an indication that irrespective of the variety used LAI will always to higher at the closest spacing level used because of the higher number of plants per unit area.

All the tomato varieties recorded higher number of flowers per plant at 60 - 45cm intra-row spacings in 1996 and 1996/97 trials at 6 WAT. This could mean that the closest intra-row spacing of 30cm is less favourable for flower production. Fruits

of the tomato varieties tested were more firm at the widest intra-row spacing of 60cm and a bit softer at the closest intra-row spacing of 30cm in 1995/96 dry season trial. This could also mean that at a denser situation of plant growth the heat in the crop environment may have made the fruits a bit softer than when the plants are more widely spaced whereby air circulation is more and the heat generated by the planting density is less high. Percent soluble solids was highest in all the fruits of the tomato varieties tested at the closest intra-row spacing of 30cm in 1996, 1995/96 and 1996/97 trials. This could also mean that the fruits were shaded more by their dense foliage as a result of the closest spacing than their counterparts at wider intra-row spacings of 45 and 60cm from the intense solar radiation which might have altered their chemical composition. Average fruit weight was highest in all the tomato varieties tested at the widest intra-row spacings of 60cm and lowest at the closest intra-row spacing of 30cm in 1995 and 1996. This seems to agree with the findings of Rajewar and Patil (1979).

The yields per hectare of the tomato varieties also varied significantly in their response to intra-row spacing levels. TI 106 and TI 182 yielded better at 45 - 30cm intra-row spacing; with TI 468 at 60cm and TI 539 at the closest intra-row spacing of 30cm. This is also an indication that TI 106 and 182 (semi-determinate) can perform better at the medium spacing of 45cm; TI 468 (an indeterminate variety) at the widest intra-row spacing of 60cm and TI 539 (determinate variety) at the closest intra-row

spacing of 30cm. These results seemed to be in consonant with the findings of Srinivasa *et al* (1988) and Moldoveanu (1977).

5.6 Correlation and Path Coefficient Analysis.

Positive and significant relationships were established between most of the characters studied indicating an interdependency between these characters. The negative association between days to 50% flowering and most other characters, including yield, implies that the higher the number of days to 50% flowering, the lower will be these characters. This is true, since the longer the vegetative phase, the more assimilates will be used for growth at the expense of reproductive phase.

Association between most growth parameters and yield and yield components were also positive and significant indicating such parameters to be important yield determinants. Relationship between yield and yield component characters also revealed yield/plant, average fruit weight and number of flowers/plant to be important yield determinants; this is in agreement with the findings of Ibrahim (1994).

The path analyses and percent contributions showed that most of the growth characters make their greatest contribution to yield (direct and indirect) through plant height and number of leaves. This is due to the fact that increased height and leaf number are synonymous with increased photo-synthetic surface area and thus greater photosynthate production which translated into higher yield (Blackman, 1919; Watson, 1952). Yield components

made their greatest contribution to yield through yield/plant and average fruit weight (direct and indirect). This is an indication that these two parameters are the greatest yield contributing factors in tomato (Amans, 1993 and Ibrahim, 1994).

5.7 Polynomial response of total fruit yield to inter and intra-row spacing.

When the Polynomial response of both the inter and intra-row spacings were examined using chi-square test for goodness of fit it was observed that the deviations between observed and expected yields for all the inter and intra-row spacing levels in all 4 seasons were not significant. However, the chi-square values for quadratic were lower than those of linearity for both the inter and intra-row spacing levels in most of the seasons (including the combined analysis), indicating the quadratic response (equation) to be a better fit than the linear response.

CHAPTER SIX

SUMMARY AND CONCLUSION

Four field trials were carried out during the 2 rainy seasons of 1995 and 1996 and 2 dry seasons of 1995/96 and 1996/97 at the Institute for Agricultural Research Farm, Samaru, Zaria (11^0 11'N' 07^0 38'E and 686m above sea level) to study the effect of inter and intra-row spacing levels on tomato (*Lycopersicon lycopersicum* Karst) varieties. The treatments consisted of three inter-row spacing levels (45, 60 and 75cm), three intra-row spacing levels (30, 45 and 60cm) and four tomato varieties (TI 106, TI 182, TI 468 and TI 539 representing Roma VF, Early Mech, 3900 line and 5-80-285, respectively). Factorial combinations of inter and intra-row spacings were allocated to the main plots while the tomato varieties were placed in the subplots in a split plot design with four replications.

The results showed that the tomato plants were more taller, had higher total dry matter (TDM) attained days to 50% flowering and days to first harvest much earlier and had heavier fruits in the two wet season trials than in the two dry seasons. However, number of leaves per plant, leaf area index (LAI), yield/plant and total fruit yield per hectare were higher in the two dry season trials than in the two wet seasons. Relative growth rate (RGR), net assimilation rate (NAR) and percent soluble solids were similar during both the wet and dry season trials. Number of flowers/plant was similar in the three trials with the exception of 1996/97 dry season were the flower number was

higher. Fruit firmness was also similar in three seasons of the trial with the exception of 1995/96 dry season were the fruits are softer than their counter parts in the other three trials.

In all four seasons of the trial, variety TI 468 was the tallest, had higher TDM, RGR, percent soluble solids and average fruit weight than the other three tomato varieties. TI 106 and TI 539 had the highest number of leaves/plant, LAI, number of flowers/plant, fruit firmness and yield/plant followed by TI 182, with TI 468 recording least in most of these parameters. NAR was highest in TI 106 followed by TI 182, TI 468 and TI 539 in that order. Days to 50% flowering and days to first harvest were significant only during the 2 dry seasons with TI 106, attaining maturity much earlier than TI 182, TI 468 and TI 539 which were at par with each other. Total fruit yield per hectare was highest in TI 539 followed by TI 106 which, in turn was higher than TI 182, with TI 468 recording the least yield in all trials.

Plant height (in 1995/96 only), LAI, RGR, percent soluble solids and total fruit yield per hectare were all observed to be highest at both closest inter and intra-row spacings of 45 and 30cm, respectively. Number of leaves per plant (1995/96), TDM (1996 and 1996/97), number of flowers/plant (1995 and 1996), days to 50% flowering (1995/96 and 1996/97), days to first harvest (1995/96 and 1996/97), fruit firmness (1995/96 and 1996/97) and yield/plant were observed to be higher at both the widest inter- and intra-row spacings of 75 and 60cm, respectively. Average fruit weight was not significantly affected by both the inter and

intra-row spacing levels in all four seasons of the trial.

Significant interactions were recorded on some of the parameters such as number of leaves per plant, TDM, LAI, number of flowers/plant, fruit firmness, percent soluble solids, average fruit weight and total fruit yield per hectare.

The results of the correlation analyses revealed significant association between most of the characters studied. The correlation was also positive for most characters, although days to 50% flowering was negatively correlated with all other characters. The path analysis revealed that indirect contribution of growth characters to yield was highest via number of leaves per plant. Yield characters contributed more via yield/plant.

The percentage contribution of growth characters on yield revealed that plant height made the highest individual contribution to yield while the combination of plant height and number of leaves made the highest combined contribution to yield. When the percentage contribution of the major yield contributors were examined, yield/plant was observed to have contributed (individually) the highest percentage to yield, while the combination of average fruit weight and yield/plant was the highest contributor to yield.

Polynomial response of total fruit yield to inter- and intra-row spacing levels were observed to be quadratic.

Based on the results obtained it could be said that:-

1. Variety TI 539 (5-80-285) followed by TI 106 (Roma VF) and. to some extent TI 182 (Early Mech) are more promising under both the dry and wet seasons tomato cultivation than TI 468 (3900 line).

2. The inter- and intra-row spacings for optimum/ adequate growth and yield of tomato for TI 539 (determinate) are 45 and 30cm, 60 and 45cm for TI 106 and TI 182 (both semi-determinates) and 75 and 60cm for TI 468 (indeterminate). respectively.

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Appendix I: Physical and chemical properties of the soil of the experimental plots in Samaru.

Composition	1995 wet season	1995/96 dry season	1996 wet season	1996/97 dry season
Soil characteristics				
pH in water (1:2.5)	5.40	5.10	5.70	5.30
PH in $Cacl_2$ (1:2.5)	4.90	4.20	4.40	4.30
Organic carbon (%)	0.72	0.51	0.64	0.49
Total nitrogen (%)	0.06	0.05	0.04	0.06
Available phosphorus (mg/kg)	6.32	1.12	8.40	1.30
Exchange bases (meq/100g)				
Ca	2.80	2.83	1.92	2.60
Mg	1.43	1.49	1.30	1.10
K	0.30	0.32	0.28	0.30
Na	0.11	0.14	0.10	0.09
C. E. C.	6.20	5.60	5.80	6.20
Particle size distribution (%).				
Sand	43	40	44	38
Silt	44	42	40	41
Clay	13	18	16	21
Textural class	Loam	Loam	Loam	Loam

Appendix II: Samaru Meteorological observations in 1995.

Month	Rain fall (mm)	Temperature (°C) Min	Max.	Relative Humidity (%) 10.00am	4.00pm	Sunshine Hrs.
January	0	10.5	28.2	31.4	21.2	NA
February	0	13.3	30.5	27.7	19.6	NA
March	0	18.4	35.8	26.3	29.8	NA
April	90.5	19.4	34.0	41.2	31.0	NA
May	45.5	17.0	34.2	68.0	44.5	NA
June	125	15.6	31.4	70.6	51.0	NA
July	193.7	21.7	29.8	79.5	66.7	NA
August	258.6	20.1	28.7	81.8	76.2	NA
Sept.	159.1	20.4	29.9	81.3	69.8	NA
Oct.	32.5	19.0	32.0	74.3	54.6	NA
Nov.	0	15.6	28.4	43.7	37.6	NA
Dec.	0	14.1	32.9	20.7	21.1	NA

N.A. Not available

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

Appendix III: Samaru Meteorological observations in 1996.

Month	Rain fall (mm)	Temperature (°C) Min	Max.	Relative Humidity (%) 10.00am	4.00pm	Sunshine Hrs.
January	0	10.3	32.3	23.6	16.5	NA
February	0	17.0	33.4	23.9	16.8	NA
March	0	20.8	37.7	31.7	30.7	NA
April	0	23.0	37.4	55.8	31.7	NA
May	158.7	21.8	34.2	69.8	47.5	NA
June	143.3	19.5	30.2	77.5	62.6	NA
July	156.7	19.0	28.2	79.4	60.5	NA
August	171.1	19.9	27.7	79.5	72.7	NA
Sept.	136.2	20.9	30.1	81.5	69.6	NA
Oct.	59.9	18.5	31.4	65.5	55.1	NA
Nov.	0	13.1	30.5	25.2	21.5	NA
Dec.	0	11.7	32.6	16.2	17.5	NA

N.A. Not available

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

Appendix IV: Samaru Meteorological observations in 1997.

Month	Rain fall (mm)	Temperature (°C) Min	Max.	Relative Humidity (%) 10.00am	4.00pm	Sunshine Hrs.
January	0	13.3	32.5	17.8	13.5	NA
February	0	13.0	29.4	14.3	12.1	NA
March	0	19.0	35.1	23.8	16.8	NA
April	47.6	21.8	35.1	57.2	34.9	NA
May	86.4	21.1	32.1	74.9	50.5	8.2
June	155.2	20.5	30.1	79.6	65.6	5.8
July	213.8	19.9	28.8	84.5	68.5	6.0
August	290.2	19.9	28.8	83.4	73.3	5.7
Sept.	200.4	19.9	28.8	83.4	73.3	5.7
Oct.	82.4	20.1	31.2	79.6	65.9	7.6
Nov.	0	14.8	32.9	43.3	30.1	8.8
Dec.	0	12.4	31.4	18.5	17.4	8.4

N.A. Not available

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

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