STUDIES ON THE EFFECT OF MEDIA, FERTIGATION, MULCHING AND IRRIGATION PACKAGE ON GROWTH, YIELD AND QUALITY OF TOMATO (*Lycopersicon esculentum Mill.*) HYBRIDS UNDER GREENHOUSE CONDITIONS

Thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science (Horticulture) to Tamil Nadu Agricultural University.

By

C. SIBIN

ID. NO. 00-620-012

DEPARTMENT OF VEGETABLE CROPS

HORTICULTURAL COLLEGE AND RESERCH INSTITTUTE

TAMIL NADU AGRICULTURAL UNIVERSITY

COIMBATORE-641003

2002


STUDIES ON GROWTH AND YIELD OF
HYBRID TOMATO UNDER GREEN HOUSE
NAME OF THE STUDENT > SIBIN.C
CHAIRMAN > Dr.V.KANTHASWAMY
GREEN HOUSE

CERTIFICATE

This is to certify that the thesis entitled " **STUDIES ON THE EFFECT OF MEDIA, FERTIGATION, MULCHING, SPACING AND IRRIGATION PACKAGE ON GROWTH, YIELD AND QUALITY OF TOMATO (*Lycopersicon esculentum Mill.*) HYBRIDS UNDER GREENHOUSE CONDITIONS"** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** to the Tamil Nadu Agricultural University, Coimbatore is a record of **bona fide** research work carried out by Mr. C. SIBIN under my supervision and guidance and no part of this thesis has been submitted for the award of any other degree, diploma or other similar titles or the prize and the work has not been published in part or full in any scientific journal or magazine

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(V. KANTHASWAMY)

CHAIRMAN

Approved by

Chairman : **(V. KANTHASWAMY)**

Members : **(S. NATARAJAN)**

(U. BANGARUSAMY)

External examiner

Date : 8/11/02

Acknowledgement

Acknowledgement

With regardful memories.....

Would it be all envisaging to offer salutations at the feet of the almighty who kindly imbued the energy and enthusiasm through ramifying paths of thick and thin of my efforts.

Words could not suffice to tell the gratitude I feel towards **Dr. V. Kanthaswamy**, Associate Professor, Department of Vegetable Crops, Horticultural College and Research Institute, Coimbatore and Chairman of the advisory committee for his inspiring guidance and transcendent suggestions that brought the progress of my post graduate programme.

Ineffable is my fervent gratitude to my members of Advisory committee **Dr. S. Natarajan**, Professor of Horticulture, Department of Vegetable Crops, Horticultural College and Research Institute, Coimbatore and **Dr. U Bangarusamy,** Professor (Crop Physiology), Department of Fruit Crops, Horticultural College and Research Institute, Coimbatore, for their valuable help and counseling in this attempt.

I sincerely thank **Dr. R. S. Azhakiamanavalan,** Dean (Hort), Horticultural College and Research Institute, for providing all facilities through out the course of investigation.

I place my sincere thanks to **Dr. D. Veeraraghavathatham,** Professor and Head, Department of Vegetable Crops, **Dr. N. Chezhiyan,** P.G. Co-ordinator, **Dr. M. Vijaya kumar,** Professor and Head, Department of Floriculture and Landscaping, **Dr. N. Kumar,** Professor and Head, Department of Fruit Crops, **Dr. R.M. Vijayakumar,** Associate Professor (Farm) and **Dr. M. Kannan,** Associate Professor (Hort), for their valuable help rendered at all stages.

I am extremely happy to replace my heartfelt reverence to **Mr. R. Venkatachalam,** Assistant Professor, Department of Vegetable Crops, Horticultural College and Research Institute, for his benevolent attitude and indefatigable attention in mounting this manuscript to fine dimension.

I thank orchard labourers, **Mr. Marimuthu,** and **Mrs. Pushpa** for their timely help in carrying out my research work without most care.

Heart filled growing love, I submit everything at the feet of my beloved parents **Sree. C. Chinnakrishnan and Smt. Meenakshy Chinnakrishnan** for caring me on their shoulders through different phases of my life till now

Words seem inadequate to express my deep sense of gratitude and indebtedness to my uncles **Sree P.K. Madhavan, Sree P.K. Gireesh** my sisters **Mrs. Seena and Miss. Sona** and my brother in law **Mr. Shaju.**

Everlasting enthusiasm and continuous unimaginable encouragement shown by solicitous friends **K.T. Vivek, N. Sajeesh kumar, Teshome Anshebo, P.S.K. Jagannath, M. Velmurugan, T.S. Prabhakaran, S. Arvind kumar, and G.R. Kumaresan** are acknowledged with pride.

My special thanks goes to **ICAR** for providing me with Junior Research fellowship and the authorities of TNAU for having permitted to utilize the computer facilities available at **Centre of excellence in Olericulture,** Horticultural College and Research Institute,Coimbatore under **World bank aided AHRDP project.**

(C. SIBIN)

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ABSTRACT

STUDIES ON THE EFFECT OF MEDIA, FERTIGATION, MULCHING AND IRRIGATION PACKAGE ON GROWTH, YIELD AND QUALITY OF TOMATO (*Lycopersicon esculentum Mill.*) HYBRIDS UNDER GREENHOUSE CONDITIONS

By

C. SIBIN

DEGREE: MASTER OF SCIENCE (HORTICULTURE)

CHAIRMAN: Dr. V. KANTHASWAMY, PhD
Associate Professor (Horticulture)
Department of Vegetable Crops
Horticultural College and Research Institute
Tamil Nadu Agricultural University,
Coimbatore. 641003.

2002

Investigations were carried out in tomato (*Lycopersicon esculentum* Mill.) with two hybrids, SH 7611 and Arka Abijith to study the performance in terms of quantitative and qualitative characters under greenhouse so as to develop a suitable production package for hybrid tomato under greenhouse. Experiments were carried out during two seasons viz., summer and kharif at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore.

The hybrids were assessed for their mean performance in respect of quantitative characters like plant height, days to 50 per cent flowering, number

of flowering cluster per plant, number of flowers per cluster, fruit setting percentage, number of fruiting clusters per plant, number of fruits per cluster, single fruit weight, polar diameter, equatorial diameter, fruit firmness, yield per plant and yield per hectare, biochemical characters like total soluble solids, total sugars, titrable acidity and ascorbic acid and physiological parameters like specific leaf area, leaf area per plant, leaf area index, specific leaf weight, crop growth rate, net assimilation rate and relative water content.

Results showed that all the treatments exhibited significant differences for various traits studied. Among the growing media, the best performance in terms of yield was noticed in T_1 with soil-compost-sand in the ratio 2:1:1, which was also manifested to excel in fruit quality compared to other growing media.

Among all the treatments, the best performance in terms of total fruit yield was recorded in T_6 with biofertilizers and K fertilizer as basal, followed by T_{10} with biofertilizers and NPK fertilizers as basal, which were also revealed to excel in fruit quality over other treatments.

Based on the above observations on yield, quality and physiological parameters, the treatment (T_6) with growing medium, soil: compost: sand (2:1:1), irrigation regime of 20 Kpa, basal application of 50:50:50 Kg ha^{-1} NPK with straight fertilizers, fertigation @ 250: 250: 250 Kg ha^{-1} NPK with water soluble fertilizers and mulching (T_6) is recommended for cultivation of hybrid tomato under greenhouse.

Introduction

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetable crops widely grown which ranks next to potato. It is an excellent source of vitamin A and C. In tropical Asia, it is an important cash-earning crop for small farmers (Villareal, 1980). It tops the list of industrial crops because of its outstanding processing qualities. The area of tomato cultivation under world is 2.92 m. ha. with a production of 82.54 million tones (Anon, 2000). In India, it is grown in an area of 0.36 million ha. with an annual production of 5.33 million tonnes (Anon, 2000). In Tamil Nadu, 2.42 lakh tonnes of tomato are produced annually from an area of 21,086 ha. (Anon, 2000), particularly from the districts of Theni, Coimbatore, Dharmapuri and Erode. Even though it is cultivated in larger area, the productivity seems to be lower.

The productivity of the crop is influenced not only by its genetic architecture, but also by the microclimate around it. The components of crop microclimate are light, temperature, air composition (CO_2 concentration and O_2 content) and nature of root medium. Under open field conditions, it is not possible to affect any control over light, temperature and air composition. A greenhouse due to its controlled boundaries permits the control over any one or more components of the microclimate.

Low cost greenhouses and polyhouses can play a vital role in tomato production in India for increasing the production and productivity. The partially controlled environment ensures desirable microclimate for good and uniform establishment of plants and their vigorous growth. It is a challenge to the technology, processes and resources of horticultural production to produce vegetables several times more to meet the needs of the expected vegetable requirement of 150 million tonnes by 2020. In these circumstances, greenhouse production offers great scope. Keeping in view of the diverse agro-climatic conditions of our country, there is an urgent need to standardize the agro techniques and also off-season production technology of the high value vegetable like tomato under greenhouse.

Greenhouse tomato production has attracted much attention in recent years. The attraction is based on the perception that greenhouse tomatoes may be more profitable than the conventional agronomic or horticultural crops. The popularity may also be due to misconceptions about how easily these crops can be grown, but it is to be noted that to get a profitable crop, it is required to be grown with accurate precision of management factors.

Growing a variety that is not the best choice or using seeds that are not of the best quality reduces the potential for success at the outset. Proper choice of indeterminate greenhouse hybrids of tomato, especially hybrids offers a great scope to be adapted to the lower light and higher humidity conditions inside the greenhouse.

Many types of growing systems for greenhouse tomatoes are available, which include Nutrient Film Technique, PVC pipes, sand, ground culture (in the soil), rock wool slabs and various types of aggregate media including peat, perlite and different types of compost mixtures. Each growing medium with different compositions and proportions has various influences on the growth of tomato and is advantageous in various situations.

The subject of fertilization is probably the most confusing among growers of greenhouse tomatoes. The keys to a successful nutrition programme include the use of fertilizer designed specially for greenhouse tomatoes, the exact quantity of fertilizer element needed and how much to be applied, the method of application and monitoring plant nutrient status by periodically taking samples for tissue analysis. The amount of irrigation inside the greenhouse should be controlled automatically. The volume of water will vary depending on the season and nature of growth of the plants. The fertigation with exact source of nutrients and quantity offers economical use of water and fertilizers.

Another most important factor for tomato in greenhouse is mulching. It is normally done with straw or polythene mulch. But it is found that polythene mulching has greater advantages over the other method in increasing production through producing a desirable microclimate around the plants by means of producing a desirable temperature, suppressing weed growth, and reducing loss of water and nutrients from the soil.

In greenhouse grown tomatoes, maintaining proper planting density is a pre-requisite. Using a higher planting density will cause the yield per plant to decrease, while the total yield will be increased due to increased plant population. The reduction per plant yield is primarily due to plants shading each other. The costs and the amount of labour required, however, increase with more plants and also overcrowding plants tend to promote disease development, since foliage does not dry readily, and sprays cannot penetrate the thick foliage.

Though attempts have been made in the recent past to standardize various management practices of greenhouse tomato, an integrated study comprising different packages of practices are lacking especially in India.

So an extensive study was conducted with the following objectives:

1. To find out a suitable medium for optimum growth, yield and quality of hybrid tomato under greenhouse.
2. To study the effect of plant nutrients, irrigation regime, mulching and spacing on growth, yield and quality of hybrid tomato under greenhouse.
3. To find out a suitable package of practices for hybrid tomato under greenhouse.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The greenhouse tomato needs an integrated approach of different management practices. Different growing media and fertigation schedules have significant influence on the photosynthetic rate and dry matter production of greenhouse tomato (Xu *et al.*, 1995). Saw dust and soil combination increases the organic matter and carbon content of growing media and enhance the yield in greenhouse cultivation of tomato (Mokrzecka, 1999).

The nutritional requirement of greenhouse vegetables depends on plant size and growth rate of both vegetative part and fruits (Adams, 1994). Fertigation of greenhouse tomato with NPK fertilizers has comparative yield advantage over conventional methods (Baskar and Saravanan, 1998). Fertigation with P fertilizers in greenhouse tomato has profound effect in producing higher marketable yield over the plants incorporated with P fertilizers (Carrijo and Hochmuth, 2000). Similarly, fertigation of greenhouse tomato with nitrogen fertilizers (Sharma *et al.*, 1994) and potassium fertilizers, especially K_2SO_4 has produced excellent results in improvement of plant quantitative and fruit qualitative characters (Borowski *et al.*, 2000). The total N, P and K uptake in greenhouse tomato plants differed between drip irrigation and conventional irrigation treatments. Nevertheless, crop requirements were consistently K>N>P (Alcantar *et al.*, 2000). Application of nitrogenous fertilizer in irrigation water was more efficient than by soil application (Candido *et al.*, 2000). Use of drip irrigation combined with water-soluble are common in greenhouse tomato cultivators of Florida. (Antonio, 1994). A significant difference was noted between conventional and organic tomato production systems in terms of growth, yield and disease incidence under greenhouse (Drinkwater *et al.*, 1999).

Domini *et al.* (2000) reported the use of Azospirillum in sustainable greenhouse tomato production. The influence of organic fertilizers on micro-organisms in tomato rhizosphere was studied by Karbauskiene (2000). Different fungal populations of Penicillium, Fusarium, Aspergillus and Trichoderma have been observed in rhizosphere of tomato, which has been attributed to the best performance of tomato under greenhouse.

Gul and Sevgican (1994) reported that growing media produced significant differences in plant quantitative characters, but has not exhibited significant differences in fruit quality characters of greenhouse tomato. F1 hybrids of tomato performed excellently in various combinations of growing media like peat, spent mushroom-compost, and volcanic tuff compared to conventional soil media in greenhouse (Celikel, 1997). Growth, yield and fruit quality of tomatoes grown on coconut fiber were not different from those grown in rock wool (Shinohara *et al.*, 2000). Narda and Luhan (1999) studied the growth dynamics of tomatoes when grown with surface drip irrigation, subsurface, and conventional drip irrigation in greenhouse. The best performance was obtained with subsurface followed by surface drip irrigation in terms of growth dynamics and yield. The coco peat is considered as a renewable peat substitute for use in horticulture. The bio-degraded coco peat is found to have lower C/N ratio, high cation exchange capacity and humic acid content (Yau and Murphy, 2000).

Xu Guimin *et al.* (1994) reported 40-60 per cent reduction in water use and 7-8 per cent increased yield when greenhouse tomatoes were grown with drip irrigation and plastic mulch. Mulching is found to give an early yield for determinate varieties, but gives high total yield for indeterminate varieties (Gul and Sevgican, 1994). Mulching with black polythene has positive effect on improving plant growth and development and getting an early yield (Ankara and Arin, 1998). Polythene mulches maintained most of the soil nitrate nitrogen of field grown tomato (Rhoads and Gardiner, 2000).

The total yield of tomato plants grown in greenhouse varies linearly with total amount of irrigation water and water use of the plant; the total yield has positive correlation with amount of irrigation water, but has adverse affect on fruit quality (Tuzel and Ul, 1994). The drip irrigation has been recognized as a sensible method of supplying water inside the greenhouses (Yuan Baozhong *et al.*, 2001).

Plant spacing greatly affects the leaf area and canopy photosynthesis of greenhouse tomato. The plants grown with narrow spacing produced higher yield compared to normal one. The main factor responsible for increase in yield was greater biomass and increased availability of total assimilates, but the narrow spacing appeared to have detrimental effects on tomato fruit size (Papado poulos and Parrajasingham, 1997).

2.1. Quantitative characters

2.1.1. Plant height

Celikel (1997) reported that the plant growth has significant correlation with yield in indeterminate tomato F1 hybrids. Plants grown under greenhouse grew more vigorously than in open field. They exhibited greater plant height due to greater cellular expansion and cell division under shaded conditions (El-

Aidy *et al.*, 1988). In an experiment with various growing media, Servetrvaris and Tancerozyyaman (1994) obtained the best growth of the plants in soil + compost combination. Gul and Sevgican (1994) reported that growing media has significant effect on truss height, which plays an important role in determining the total yield of the crop. Eltez (1994) reported higher plant height in egg plant and pepper when grown in peat and perlite combinations under greenhouse compared to conventional soil medium. Alan and Zulkadir (1994) reported no significant difference in plant height between soil and peat + perlite combination, but significant difference in plant height was reported between different peat and perlite combinations.

While using black polythene as mulch in greenhouse, tomato plants performed well in respect of plant growth characters, such as, height and stem diameter (Eltez and Tuzel, 1994). Mulching has positive correlation with plant growth in indeterminate tomato varieties (Pakyurek , 1994).

Decreasing the frequency of irrigation reduced plant growth, height and stem thickness in greenhouse tomato (Byary and Al Sayed, 1999). Tuzel and Ul (1994) reported that the height of the plant and stem diameter varied significantly with different irrigation interval. Neeraj jain *et al*, (2000) reported that the plant height was maximum for greenhouse tomato irrigated with drip system and combined with black polythene mulch.

Sharma *et al.* (1994) found that the application of nitrogen @ 200 $Kg.ha^{-1}$ and phosphorus @ 60-80 $Kg.ha^{-1}$ in tomato hybrids significantly improved the plant height and fruit characteristics. Taller plants were found in greenhouse tomato grown with the combinations of organic matter and NPK applications (Youssef *et al.*, 2001).

The plant spacing has positive correlation with plant height as reported by Papadopoulos and Pararajsingham (1997). A consistent increase in plant height and internodal length with closer spacing of 23, 30, and 38 cm was reported by Papadopoulos and Ormrod (1991). Similar observations of plant growth character were reported by Sreenivasan *et al.* (1999) in field grown tomato.

Positive correlation between plant height and fruit yield has been reported by Anbu (1978), Ratnamnadar *et al,* (1980), Kanthaswamy (1988), Aruna (1992), Jawaharlal (1999) and Mala (2000). Indu Nair (1995) reported that significant association was noticed between plant height and node of first flower. Aruna and Veeraraghavathatham (1997) reported that plant height was negatively correlated with leaf area, single fruit weight, reducing sugars, ascorbic acid and acidity. A negative correlation between plant height and fruit weight, as well as number of fruiting clusters was observed by Kumar *et al.* (1980). Plant height recording a negative correlation with total yield in greenhouse tomato as reported by Arunkumar (2000).

2.1.2. Days to 50 per cent flowering

Delay in flowering can lead to late fruit production. Days to 50 per cent flowering indicate the earliness of a crop.

Gonzalez and Ruz (1999) reported the importance of nitrogen fertigation in greenhouse tomato for getting an early yield. Nicola and Basoccu (2000) reported that increased fruit earliness was linearly enhanced by increase in nitrogen supply during greenhouse transplant growth. Singh (2000) studied the effect of urea on growth and yield of hybrid tomato cultivar "Rashmi" and found that the use of urea delayed initiation of flowering and fruit setting.

The tomato crop grown in plastic tunnels and applied with organic matter + NPK fertilizer produced early yield as reported by Youssef *et al.* (2001).

Use of soil-less growing media was beneficial in unheated greenhouse for increasing the earliness was reported by Gul and Sevgican, 1994. The early production of greenhouse tomatoes has been observed more in soil-less cultivation than in soil cultivation (Tesi *et al.,* 1994). Celikal (1997) reported that greenhouse tomato plants grown with peat + volcanic tuff + spent mushroom compost in 1:1:1 ratio gave early yield. Okur *et al.* (1999) reported that plant grown in sandy soil mixed with compost produced early yield. Early and total yields were higher on rock wool media compared to peat in green house tomato as reported by Oswecimski et al (1992).

Pakyurek (1994) reported that mulching with transparent plastic increased the earliness. Difference in earliness was reported for transparent mulching and black polythene mulching by Abak *et al.* (1994). Ankara and Arin (1998) reported that tomato crop grown in greenhouse produced highest early yield when pruned at 4^{th} truss and mulched with any mulch.

Papadopoulos and Ormrod (1991) reported that there is no correlation of irrigation frequency and early yield of greenhouse tomato. Significant and positive correlation of days to 50 per cent flowering with yield was recorded by Sooryanathasundaram *et al.* (1994), Indu Nair (1995), Padmini (1995), Verma *et al.* (1997) and Hazarika and Das (1998). Aruna and Veeraraghavathatham (1997) observed negative association for this trait with yield. A positive and significant correlation between this trait and fruit yield was reported by Arunkumar (2000) in greenhouse tomato.

2.1.3. Number of flowers per plant

The number of flowering clusters per plant and number of flowers per cluster are important parameters for assessing the yield. The tomato cultivar "Capello" recorded an average number of seven flowers per truss when grown under greenhouse conditions (Auerswal *et al.,* 1996) Under unheated glasshouse, the average number of flowers per cluster was 23.50 in "Cario" F1 hybrid of tomato (Ercan and Varel, 1994). The number of flower buds formed on each of first ten trusses of tomato plant varied between 9 and 11 under glass house condition (Cockshull *et al.*, 1992). The rate of flower cluster development was reduced when greenhouse tomatoes were grown at a closer spacing of less than 45 cm between plants (Papadopoulos and Pararajasingham, 1997).

The number of flowering clusters per plant exhibited high positive association with number of flower clusters and number of fruits per plant in greenhouse tomato, but not with fruit yield (Arunkumar, 2000).

2.1.4. Number of fruits per plant

Alan and Zulkadir (1994) reported that a combination of pumice, peat and perlite in the ratio 8:1:1 gave significant differences in fruit number compared to other combinations and this was found to have significantly higher number than pure soil as growing media. Servetvaris and Tancerozyyaman (1994) found significant difference between perlite combinations in total fruit number per plant. Expanded clays as growing media fertigated with NPK nutrient solution performed exceptionally well in terms of productivity (Calabretta and Nucifora, 1994). Dobrimilska (1998) found no significant effect of growing medium on number of fruits, when tomato plants were grown in greenhouse with a media composition of peat, soil and cattle manure, sand and brown coal. Mokrzecka (2000) reported that tomato plants grown in 3:1 mixture of sawdust and soil and fertigated with 0.8 g nitrogen per cm^3 gave the highest number of fruits per plant. The tomato cultivar 'Gardener' registered highest fruit number and total yield on biodegraded coco peat compared to conventional soil media (Yau and Murphy, 2000).

Papadopoulos and Ormrod (1991) showed no effect of irrigation frequency on total number of fruits or yield of greenhouse grown tomato. Xu *et al.* (1995) reported that in greenhouse tomato, potential evapo-transpiration dependent electrical conductivity variation influences photosynthetic capacity, plant growth and number of fruits per plant and hence, the level of irrigation is found to have profound influence on plant growth and yield. Large variations were found among tomato cultivars in number of fruit clusters per plant and number of fruits per cluster (Byary and Al Sayed, 1999).

Boztok and Gul (1992) reported that narrow spacing reduced the total number of fruits per plant but increased the total yield in greenhouse tomato, which was attributed to higher number of fruits per square meter.

The number of fruits per plant had significant and positive association with fruit yield. This was also reported by Kanthaswamy (1988), Khattra *et al.* (1990), Sooryanathasundaram (1994), Indu Nair *et al.* (1995), Singh *et al.* (1997). Aruna and Veeraraghavathatham (1997) observed negative association between number of fruits and total yield. A negative correlation of number of fruits with fruit yield and positive correlation with fruit setting percentage was observed in greenhouse tomato by Arunkumar (2000).

2.1.5. Fruit setting percentage

Plant spacing had no effect on fruit setting except at extreme shading, but a close spacing reduced fruit set in spring grown greenhouse tomato (Papadopoulos and Ormrod, 1991). The detrimental effect on fruit set is because of the inadequate supply of the photosynthates to the plant stand. Sato *et al.* (2000) reported that the cultivar difference in pollen release and germination under heat stress are the most important factors determining the ability of greenhouse tomato to set fruit. Varga *et al.* (2000) studied the effect of temperature and water supply on greenhouse tomato and found that the total yield and fruit set were best in optimum irrigated field compared to regular irrigated and scantly irrigated fields. Slight reduction in water supply decreased fruit set in greenhouse grown tomato but found to have an enhancing effect on fruit quality (Veit kohler *et al.,* 2001).

In tomato production, the important characters determining the fruit yield are efficient fruit set and production of marketable sized fruit. Fruit set is mainly determined by pollination and fertilization. The truss vibration increased fruit set significantly in first three trusses compared with control (no vibration). This positive effect of vibration is attributed to easy transfer of pollen grain to stigma. Tomato truss vibration has been used as an efficient method by more than 50 per cent of the growers and more than 37 per cent area in Florida (Antonio, 1994). Cetinkaya (1999) reported significant increase in fruit set and yield in greenhouse tomato with vibration.

Fruit setting percentage in greenhouse tomato has positive correlation with yield in greenhouse tomato (Arunkumar, 2000)

2.1.6. Single fruit weight

Single fruit weight is an important character determining the individual fruit quality. Saglam and Yagan (1999) reported that the truss pruning significantly affect the total yield by decreasing the number of fruits per truss and increasing the average fruit weight and quality.

Alan and Zulkadir (1994) reported the variation between different treatments in mean fruit weight of greenhouse tomato, when grown with perlite, peat and pumice combinations. The best result was obtained when perlite and pumice was used in the ratio of 1:1. Baskar and Saravanan (1998) reported the increase in single fruit weight of tomato on using coir pith as growing medium. Fruit weight varies greatly among the perlite combinations and ordinary soil + compost mixture in greenhouse grown tomatoes which has been reported by Servetvaris and Tancerozyyaman (1994).

Sharma *et al.* (1994) reported the boosting effect of fertigated phosphorus on marketable yield of greenhouse tomato. Similar results were obtained by Carrijo and Hochmuth (2000) when fertigated with P and N solutions. Ymeri *et al.* (2000) reported that slow release fertilizers have a boosting effect on yield of greenhouse tomato grown on soil-less media compared to control, but have lowest TSS and titrable acidity. Average fruit weight being highest for regularly irrigated stands compared to scantly irrigated field in greenhouse tomato has been shown by Varga *et al.* (2000).

Pakyurek (1994) obtained the highest single fruit yield in greenhouse tomato using transparent mulching. Tekinel (1994) observed a positive increase in single fruit weight in greenhouse grown cucumber when mulched with black polythene combined with drip irrigation. Siwek et al. (1994) studied the effect of mulching on change in microclimate and on growth and yield of sweet pepper in plastic tunnel compared to control (without mulch) and found that single fruit weight was higher in black polythene mulched plants.

Single fruit weight was greatly influenced by spacing, and reduced spacing has negative association with single fruit weight (Papapdapoulose and Pararajsingham, 1997).

Fruit weight had high significant and positive correlation with tomato fruit yield, as reported by Palaniappan *et al.* (1982), Mishra and Mishra (1989), Selvam (1994), Aruna and Veeraraghavathathatham (1997) Mageswari *et al.* (1997) and Hazariaka and Das (1998). On the other hand, Raijadhev *et al.* (1970) and Susheela *et al.* (1990) reported negative association of fruit weight with yield. Arunkumar (2000) reported a high and positive correlation of single fruit weight with fruit yield in greenhouse tomato.

2.1.7. Fruit size

Fruit size includes polar and equatorial diameters of the fruit. Doriraj (1981) found that the differences among cultivars and hybrids for polar and equatorial diameters were highly significant. Jayajasmine (1991) reported a maximum of 5.64 cm and 6.48 cm of polar and equatorial diameter respectively in indeterminate tomato F1 hybrid FM_2.

The growing media have significant effect on fruit size was reported by Gul and Sevgican (1994). There was no significant effect on fruit size when greenhouse tomatoes were grown in rock wool, peat and spent mushroom-compost combinations (Abak *et al.*, 1994).

Tuzel and Ul (1994) reported that fruit size varied linearly with the amount of irrigation water. Fruit diameter and length were increased along with total yield when indeterminate tomato hybrid was grown with transparent plastic mulching in tunnels (Pakyurek, 1994). Significant increase in fruit size was reported in greenhouse tomato fertigated with nitrogen and phosphorus (Sharma *et al.*, 1994). Narrow spacing was found to be detrimental on fruit size (Papdapoulose and Pararajasingham, 1997). Similar observations have been made by Ankara and Arin (1998). Black mulch has been found to have positive correlation with fruit size in greenhouse grown tomato as evidenced by findings of Siwek *et al.* (1994).

The polar diameter and equatorial diameter have positive and significant correlation with yield as reported by Arunkumar (2000).

2.1.8. Total fruit yield

Servetvaris and Tancerozyyaman (1994) in his study on various growing media opined that there was no significant difference in yield of greenhouse grown tomato between treatments. Use of soil less growing media was beneficial in unheated greenhouse both in respect of earliness and total yield which was reported by Gul and Sevgican (1994). Eltez (1994) found that the peat and perlite combinations have increased the total yield of eggplant and pepper in greenhouse condition. Alan and Zulkadir (1994) found that growing media had significantly influenced the yield and obtained maximum yield in greenhouse tomato when grown with a combination of pumice, peat and perlite in the ratio 2:1:1. The total yields with different media were significantly higher than in pure soil. The total yields of pepper when grown with different media differed among media. (Padem and Alan, 1994). The total fruit yield of F1 hybrid tomato "Fantastic" when grown under greenhouse was excellent with growing media combination of peat and volcanic tuff (Celikel, 1997). Baskar and Saravanan (1998) reported that the best performance of tomato in terms of fruit yield was when grown in combination of 75 per cent soil and 25 per cent coir pith. Mokrzecka (2000) reported that adding saw dust to the soil increased the organic matter content of soil but reduced nitrogen, potassium, calcium and magnesium in greenhouse tomato.

Highest total yield of greenhouse tomato was reported on plants pruned at 8th truss and mulched with any mulch (Ankara and Arin, 1998). Mulching was found to give a high total yield of indeterminate tomato varieties (Pakyurek, 1994). Abak *et al.* (1994) found that yield differences due to mulching was not significant. Tekinel (1994) reported the maximum yield in greenhouse cucumber crops grown with drip irrigation and black plastic mulches. Abak *et al.* (1994) found that the yields of organically grown greenhouse tomato were not improved by transparent mulching. Siwek *et al.* (1994) studied the effect of mulching on change in microclimate and growth and yield of sweet pepper in plastic tunnel compared to control (without mulch). Truss pruning was found to greatly influence the total yield of greenhouse tomato as reported by Saglam and Yagan (1999). Black mulch produced a total and a marketable yield of 10.3 per cent higher than control. Jankauskiene and Brasaityte (1999) reported that spacing had significant effect on total fruit yield. Tomatoes planted in greenhouse at a spacing of 30 cm produced 3.5-22.7 per cent higher yield compared to 40 cm spacing, however the later produced fruits with size 7.3-8.9 per cent larger compared to former. Raina *et al.* (1999) reported that polythene mulching combined with drip irrigation raised the field grown tomato yield to 23.25 tonnes ha^{-1} compared to open field yield of 11.95 tonnes ha^{-1}.

Eltez (1994) used different growing media along with different mulches in increasing the yield of greenhouse tomato and obtained the best results with perlite medium and black polythene mulching. From a greenhouse experiment with fertigation management of growth and photosynthesis of tomato plants, it was found that potential evapo-transpiration dependent electrical conductivity variation increased the photosynthesis capacity, plant growth and yield of greenhouse tomato plants (Xu *et al.*, 1995). Total fruit yield was increased in greenhouse when sand or clay soil was amended with compost (Okur *et al.*, 1999). Fertigation was found to enhance the yield by 8.72 per cent over conventional method of fertilizer application (Baskar and Saravanan, 1998). Fertigation with phosphorus fertilizers was been found to have an added advantage in terms of fruit yield over conventional method of application (Carrijo and Hochmuth, 2000). Mockrezka (2000) reported that saw dust mixed with soil in the ratio of 3:1 and fertilized with 0.8 g nitrogen cm^{-3} gave the highest yield in greenhouse tomato. Fruit production in greenhouse grown tomato was consistently enhanced by fertigation (Alcanter *et al.*, 2000). Papadopoulos (1998) reported a significant increase in total yield of greenhouse grown tomato fertigated with urea phosphate compared to Monoammonium phosphate or Diammonium phosphate.

The total yield (number of fruits m^{-2}) has positive correlation with amount of irrigation water and water use of the plant (Tuzel and Ul, 1994). The total yield and marketable yield of tomato vary significantly among various irrigation regimes applied as drip irrigation in greenhouse (Coelho *et al.*, 1994). Papadopoulos and Pararajasingham (1997) reported that irrigation frequency has no effect on total and early yield in greenhouse tomato. Duraiswamy *et al.* (1999) observed the highest fruit yield in crops supplied with organic fertilizers (Azospirillum + composted coir pith + FYM) than those supplied with inorganic nitrogen. Among the organic fertilizer, coir pith compost resulted in highest fruit yield (14.68 $t.ha^{-1}$). There was significant difference in water use efficiency and total yield among different levels of irrigation with mulching and control (Neeraj jain *et al.*, 2000).

The highest yield has been reported in greenhouse tomato grown with most irrigated treatments. But the irrigation with restriction of 80 per cent electrical conductivity was the most efficient in water use (Candido *et al.*, 2000).

2.1.9. Fruit firmness

Fruit firmness is measured by epidermal resistance and higher epidermal resistance values indicate tougher fruits. The irrigation rates have been found to have significant influence on fruit toughness as reported by Tuzel and Ul (1994), as irrigation rates reduced, fruits with tough skin obtained. The importance of potassium fertilizers on fruit peel thickness was shown by (Borowski *et al.*, 2000). Organic matter mixed with mineral fertilizer have shown best results in peel thickness when tomatoes were grown in plastic tunnels (Youssef *et al.*, 2001). Plaut and Grava (2000) showed that tomato plants suffering from water stress developed better peel thickness.

2.2. BIOCHEMICAL CHARACTERS

Regarding tomato, the relative importance of different criteria for bio-chemical characters is not the same for consumer, nutritionist, retailer, shipper, and processer. Comparing appreciation of sensory characters with analytical data have shown that the soluble solids and acid content gave a good idea of the overall flavor of the fruit (Stevens *et al.*, 1978). Tomato production in greenhouse is typically intensive and its quality has to be studied, as people generally think that quality and quantity are antagonistic (Denise blanc, 1986). Tomatoes grown in soil-less media have significant difference in organoleptic properties compared to plants grown in soil media in terms of aroma, sweetness, firmness and visual appearance (Grungen *et al.*, 2000).

2.2.1. Total soluble solids

Stevens *et al.* (1978) reported that the indeterminate cultivars showed higher TSS content than the determinate cultivars. Orzoleck and Angell (1975) reported that the wide variations in soluble solid content occur as a result of both environmental and genetic factors. Organic and inorganic fertilizers did not significantly affect T.S.S in greenhouse tomato (Duraiswamy *et al.*, 1999). Precise irrigation scheduling is necessary in order to obtain good production of tomato with high quality level, particularly the correct management of irrigation, and the introduction of regulated deficit irrigation concepts can increase soluble solids without severe yield reductions (Battilani *et al.*, 2000).

Soluble solid content of fruit was lowest with regular irrigation as reported by Varga *et al*, (2000). Padem and Alan (1994) reported that the combination of pumice and peat substrate increased the TSS of the greenhouse grown pepper fruit significantly. Gul and Sevgican (1994) reported highest TSS in greenhouse tomato using 1:1 peat and sand combination as growing media. Abak *et al.* (1994) reported the highest soluble solids in peat compared to soil and other combinations of growing media. Sen and Sevgican (1999) reported that greenhouse tomatoes, grown in peat and perlite medium in the ratio 3:1, was found to have high TSS and juice contents compared to soil medium.

Soluble solids content of fruits differed significantly at the time of harvest and storage with peat and nutrient solution media (Gormley and Gen, 1978). Increasing potassium fertilizer can induce magnesium deficiencies, which ultimately lead to decrease in TSS (Mars *et al.*, 1985). The ratio of nitrogen to potassium in liquid fertilizer as found to have an effect on the TSS content of greenhouse tomato (Hardh and Takala, 1979). An increase in nitrogen and potassium fertliser in feeding the greenhouse tomato increased TSS as reported by Wright and Harris (1985).

TSS had positive and significant correlation with yield per plant was reported by Manivannan and Irulappan (1986), and Selvam (1994), while negative correlation was recorded by Khattra *et al.* (1990), Padmini (1995) and Indu Nair (1995). Similarly TSS had negative correlation with mean fruit weight as reported by Aruna and Veeraragavathatham (1997).

2.2.2. Acidity

Adsule *et al.* (1980) reported that acidity level was one of the most important factors in determining the intensity of tomato flavor. Tomato flavor and taste have been greatly influenced by acidity as reported by Candido *et al.* (2000).

Organic and inorganic fertliser application had not significantly affected the acidity of greenhouse grown tomato fruits (Durai swamy *et al.*, 1999). Dorais *et al.* (2001) reported that the fertigation with various nutrient solutions differing in electrical conductivity exerts significant difference in fruit quality including fruit acidity.

Baskar and Saravanan (1998) reported that in field grown tomato with 75 per cent soil + 25 per cent coir pith combination significantly increased the fruit acidity. FYM added to growing media was found to increase the fruit titrable acidity of greenhouse tomato (Mars *et al.*, 1985). Buret and Eldyprat (1985) observed lower acidity in fruits from soil less culture compared to conventional soil system. Gul and Sevgican (1994) reported that growing media had no significant effect on fruit quality characters including titrable acidity. There was no significant difference in fruit acidity between different growing media like peat, compost and volcanic tuffs as reported by Celikel (1997). Okur *et al.* (1999) obtained similar results when compost was added to sandy or clayey soil in greenhouse tomato. Alan and Zulkadir (1994) reported the highest titrable acidity in sand and lowest in perlite + pumice combination in the ratio of 1:1.

Tuzel and Ul (1994) found that titrable acidity of the fruit tended to decrease at the highest amount of irrigation in a greenhouse study conducted to determine the optimum level of irrigation regime in tomato. Increasing the irrigation favoured the moisture content of the fruit, which had a dilution effect on titrable acidity content. Byary and Al Sayed (1999) found great variations among different cultivars for different irrigation regimes for total fruit acidity. Acidity is found to be significantly different in peat and nutrient solution media (Gormley and Gen, 1978). Xu huilan *et al.* (2000) reported that concentration of sugar and organic acids were higher in plants grown with organic fertilizers.

An acidity range of 0.5 to 0.7 percentage was suggested to be the most desirable value for processing tomatoes (Andryushechenko and Shilina, 1990). In a study, Naniwal *et al.* (1992) registered a range of 0.2 to 0.5 per cent acidity among the genotype studied. Aruna and Veeraragavathatham (1997) reported that the acidity had significant positive correlation with yield in tomato.

2.2.3. Ascorbic acid

Abak *et al.* (1994) reported highest vitamin C content in tomato fruits produced in soil system compared to peat and rock wool combinations under greenhouse. Gul and Sevgican (1994) obtained highest vitamin C in 1:1 growing medium of peat and sand in greenhouse tomato. Padem and Alan (1994) found that for greenhouse pepper, vitamin C had no significant effect on media. Lowest ascorbic acid content was obtained in 1:1 peat and perlite combination and highest in pure perlite as growing media (Alan and Zulkadir, 1994).

Total ascorbic acid was found to be higher with application of inorganic nitrogen alone. Ascorbic acid significantly differed for tomato crops grown in peat and nutrient solution media (Gormley and Gen, 1978). Microbial inoculants were found to increase vitamin C contents in fruits of greenhouse tomato (Xu Huilan et al., 2000). Youssef *et al.* (2001) reported that organic matter and mineral fertilizer combination helped to produce fruits with high vitamin C content.

Lower and Thompson (1967) observed that ascorbic acid content of tomatoes was related to fruit size as well as locular content and depended on the amount of fruit surface exposed to light. According to Andryushechenko and Shilina (1990), a minimum level of 25 to 30 mg 100 g^{-1} ascorbic acid is needed for processing cultivars. Naniwal *et al.* (1992) observed a range of 20.10 to 31.02 mg 100g^{-1} of ascorbic acid in tomatoes. EL-Ghani *et al.* (1996) reported the highest ascorbic acid contents in "Dora" and "Peto Pride" compared to "Jackal" and "Royal flush" varieties of tomato.

Indu Nair (1995) recorded a negative association for ascorbic acid and yield in tomato, whereas, a positive and significant correlation was observed for ascorbic acid and yield by Aruna and Veeraragavathatham (1997).

2.2.4 Total sugars

The minimum requirement of total sugars for processing tomato was reported to be 5.5 per cent (Andryushechenko and Shilina, 1990). Sadasivam and Srinivasagopal (1974) reported a total sugar content of 2.96 and 3.31 per cent in cultivars Co.1 and Co.2 respectively. Buret and Eldyprat (1985) reported higher total sugar content of fruits from soil less culture compared to conventional soil culture.

Increasing the potassium fertilizer reduced magnesium content and thereby reducing sugar content of fruits in greenhouse grown tomato as has been reported by Mars *et al.* (1985).

3.Physiological characters

3.1.Leaf growth characters

Leaf growth is contributed by parameters like specific leaf area, specific leaf weight, leaf area per plant and leaf area index.

The greenhouse tomato with indeterminate growth type, have high leaf area index because of vertical utilisation of space. High leaf area indices gave high photosynthetic photon flux density (P.P.F.D) and resulted in higher canopy net photosynthesis and were responsible for exceptionally high yield of greenhouse tomato (Papadopoulos and Pararajasingham, 1997).

Water deficit decreased the number of leaves per plant in greenhouse tomato as reported by Byary and Al Sayed (1999), whereas, Eltez (1994) reported that the leaf number was not affected by the growing media in greenhouse tomato. Gul and Sevgican (1994) reported that growing media had significant influence on leaf growth. Tuzel and Ul (1994) reported that the leaf number of greenhouse grown eggplant and pepper with 3:1 combination of peat and perlite as growing medium was found to be maximum compared with other combinations.

The maximum fresh weight of leaf in greenhouse tomato was obtained with ammoniacal nitrogen as reported by Alberto *et al.* (1986) and leaf fresh weight was found to have positive correlation with fresh fruit weight.

Boztok and Gul (1992) studied the effect of plant density on the leaf area of greenhouse tomato and found that the yield was positively correlated with leaf are index. The higher LAI was attributed to increase in leaf number and reduced spacing. The plants grown with narrow spacing were found to have reduced leaf area. Leaf area was reported to be maximum for greenhouse tomato irrigated with drip system combined with black plastic mulch (Neeraj jain *et al.*, 2000). The plant height and number of leaves vary significantly among various soil-less media like pumice, perlite and pumaceous perlite as reported by Olympios *et al.* (1994).

3.2. Plant growth characters

Plant growth is measured by crop growth rate, net assimilation rate and relative water content. Crop growth is expressed as increase in biomass accumulation per unit area per unit time (Euvelink, 1995). Stem, leaf and root fresh weight were positively correlated with fruit fresh weight (Alberto *et al.*, 1986). Addition of carbonized rice hulls to the growing medium has positive effects on growth parameters like relative growth rate, crop growth rate and net assimilation rate. (Kaempf and Jung, 1991). This has been found to be due to increase in fresh weight of stem, leaf and dry weight of tomato plants grown in carbonized hulls. Fresh and dry weight of stems of greenhouse tomatoes grown in peat, perlite, and compost combinations were reported to be higher than with compost alone (Eltez, 1994). Vegetative growth and total yield of greenhouse grown tomatoes have been reported to be higher in rock wool medium than in soil system, but the percentage of marketable fruits were higher in the soil system (Iwasaki *et al.*, 1999).

The fertigated nitrogen was found to have positive correlation with stem and leaf fresh weight and dry weight (Gonzalez and Ruz, 1999). Mean fresh weight and dry weight of the plant have been increased in peat as growing medium than in shredded bark as growing medium due to nitrogen deficiency of plants grown in shredded bark medium as reported by Chilton *et al.* (1978). By combining successfully the mineral nitrogen with slow releasing nitrogen fertilizers, growth can be successfully improved in bark compost as evidenced by the dry weight tendencies of tomato crop. (Gormely and Gen, 1978).

Kim Yeong Bong *et al.* (2000) found that tomato plants drip irrigated at three moisture levels were found to have higher relative water content (RWC) values at higher moisture levels. Rao *et al.* (2000) recorded a low RWC value in tomato cultivars as a result of water stress and in turn negatively affecting the yield. Heat stress results in low moisture level and low fruit set in tomato as reported by Sato *et al.* (2000).

4. Nutrient status of media and plant.

Nicola and Basoccu (2000) found that soil nitrogen content of field grown tomato has positive correlation with earliness. Faria *et al.* (1999) reported that the soil P content has profound effect on quality of field grown tomato. Increasing nitrogen level in the soil, evidenced by plant nutrient studies was negatively associated with yield as reported by Singh (2000). The plant N, P and K content was found to be a good indication of plant health and was positively correlated with yield (Santos *et al.*, 2001). Rhoads and Gardiner (2000) reported that residual nitrogen in soil depend on nitrogen application rate, crop uptake and loss of nitrogen in greenhouse tomato. Deficiency of nitrogen, evidenced by soil nutrient studies, resulted in lower yield of greenhouse tomato (Bot *et al.*, 2001). The combinations of nitrate fertilizers and urea in organic media increase growth and yield of greenhouse tomatoes as reported by Ikeda *et al.* (1999). They also found that nutrient content of medium in greenhouse tomato was positively correlated with yield.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

3.1.Materials

The tomato (*Lycopersicon esculentum Mill.*) indeterminate hybrid SH 7611 was chosen for the study. The existing popular tomato hybrid Arka Abhijith was chosen as a base for comparison of the performance of the hybrid under various package of practices under greenhouse condition.

3.2.Methods

The investigations were carried out at the Department of Vegetable Crops, Horticultural College and Research Institute, Coimbatore during May 2001 to January 2002 (Kharif) and from February 2002 to August 2002 (Summer) at the college orchard greenhouse. This is situated between $11^{0}02'$ North latitude and $77^{0}03'$ East longitude and at an altitude of 426.72 m above MSL.

The treatments (Table.1.) were envisaged based on the research project entitled "NATP on Protected cultivation of Vegetables for plains" sponsored by ICAR to TNAU Coimbatore centre.

A set of standard packages for growing an indeterminate hybrid tomato (SH 7611) in greenhouse was used as a check (T_1) and in the different packages, one of the components for the respective package was modified so as to study its effect on growth, yield and quality of hybrid tomato under protected cultivation. As in other cases in one of the treatment packages, the variety component was substituted with Arka Abijith, a semi determinate hybrid.

The experiments were carried out in a greenhouse of 12 m length and 9 m breadth. The entire area in the greenhouse was divided in to 12 beds each having 3.76 m length and 1.26 m breadth. Each bed was further divided in to 3 sections with length of 1.24 m and breadth of 1.26 m, containing 9 plants in all treatments except T_{12}, which had 12 plants per section.

The experiments were laid out in randomized block design with 12 treatments replicated thrice. The treatments consist of 1) Growing media of Soil: Compost: Sand (2:1:1), Soil: Compost: Sawdust (2:1:1), Soil: Compost: Paddy husk (2:1:1), Soil: Compost: Coco peat (2:1:1).

2) Irrigation regimes of 20 Kpa and 40 Kpa, (moisture level measured with tensiometer placed at a depth of 30 cm between the two plants within a row (New and Roberts, 1973).

3) Mulching with black polyethylene and without mulching.

4) Fertigation with water soluble and straight fertilizers (fertilizers were mixed in dossetron at the rate of 250: 250: 250 kg NPK ha^{-1}).

5) Basal application of K alone and NPK fertilizers with biofertilizers azospirillum and phosphobacteria.

6) Top dressing of NPK in five splits

7) With reduced spacing of 30 × 22.5 cm.

Table.1. TREATMENT DETAILS

Production details	**T_1 (control)**	**T_2**	**T_3**	**T_4**
Hybrid	SH 7611	SH 7611	SH 7611	SH 7611
Growing medium	**Soil: Compost: Sand (2:1:1)**	**Soil: Compost: Sawdust (2:1:1)**	**Soil: Compost: Coco peat (2:1:1)**	**Soil: Compost: Paddy husk (2:1:1)**
Fertilizer schedule	➢ Basal 50: 50:50 Kg ha^{-1} NPK. ➢ Fertigation @ 250:250:250 kg ha^{-1} NPK with water soluble fertilizers	➢ Basal 50: 50:50 Kg ha^{-1} NPK. ➢ Fertigation @ 250:250:250 kg ha^{-1} NPK with water soluble fertilizers	➢ Basal 50: 50:50 Kg ha^{-1} NPK. ➢ Fertigation @ 250:250:250 kg ha^{-1} NPK with water soluble fertilizers	➢ Basal 50: 50:50 Kg ha^{-1} NPK. ➢ Fertigation @ 250:250:250 kg ha^{-1} NPK with water soluble fertilizers
Irrigation regime	20 kpa	20 kpa	20 kpa	20 kpa
Mulching	With mulch	With mulch	With mulch	With mulch
Spacing	60×45 cm	60×45 cm	60×45 cm	60×45 cm

Table.1. TREATMENT DETAILS (contd..)

Production details	T_5	T_6	T_7	T_8
Hybrid	SH 7611	SH 7611	SH 7611	SH 7611
Growing medium	Soil: Compost: Sand (2:1:1)	Soil: Compost: Sand (2:1:1)	Soil: Compost: Sand (2:1:1)	Soil: Compost: Sand (2:1:1)
Fertilizer schedule	➢ Basal 50: 50:50 Kg ha-1 NPK. ➢ Fertigation @ 250:250:250 kg ha-1 NPK with water soluble fertilizers	➢ **Basal 50 Kg ha-1 K + Azospirillum + phosphobacterea** ➢ Fertigation @ 250:250:250 kg ha-1 NPK with water soluble fertilizers	➢ Basal 50: 50:50 Kg ha-1 NPK. ➢ **Fertigation @ 250:250:250 kg ha-1 NPK with straight fertilizers**	➢ Basal 50: 50:50 Kg ha-1 NPK. ➢ Fertigation @ 250:250:250 kg ha-1 NPK with water soluble fertilizers
Irrigation regime	**40 kpa**	20 kpa	20 kpa	20 kpa
Mulching	With mulch	With mulch	With mulch	**Without mulch**
Spacing	60×45 cm	60×45 cm	60×45 cm	60×45 cm

Table.1. TREATMENT DETAILS (contd..)

Production details	T_9	T_{10}	T_{11}	T_{12}
Hybrid	**Arka Abijith**	SH 7611	SH 7611	SH 7611
Growing medium	Soil: Compost: Sand (2:1:1)	Soil: Compost: Sand (2:1:1)	Soil: Compost: Sand (2:1:1)	Soil: Compost: Sand (2:1:1)
Fertilizer schedule	➢ Basal 50: 50:50 Kg ha-^{1} NPK. ➢ Fertigation @ 250:250:250 kg ha-^{1} NPK with water soluble fertilizers	➢ **Basal 50:50:50 Kg ha-^{1} NPK + Azospirillum + phosphobacterea** ➢ Fertigation @ 250:250:250 kg ha-^{1} NPK with water soluble fertilizers	➢ Basal 50: 50:50 Kg ha-^{1} NPK. ➢ **Top dressing of NPK In 5 splits.**	➢ Basal 50: 50:50 Kg ha-^{1} NPK. ➢ Fertigation @ 250:250:250 kg ha-^{1} NPK with water soluble fertilizers
Irrigation regime	20 kpa	20 kpa	20 kpa	20 kpa
Mulching	With mulch	With mulch	With mulch	With mulch
Spacing	60×45 cm	60×45 cm	60×45 cm	**30×22.5 cm**

The plants were pruned to single stem in all the treatments. The greenhouse was fumigated with Formalin 1 per cent, kept covered for two weeks, and fully ventilated before transplanting. Nursery was prepared in potting plugs (Plate 4.) cups and seedlings were transplanted after twenty-five days inside the greenhouse as per the treatments.

3.3. OBSERVATIONS

Two plants in each treatment were marked at random and utilized for recording observations on the following characters and mean values were subjected to statistical analysis. Five well-developed fruits were randomly selected from each plant for recording observations on fruit characters.

3.3.1.QUANTITATIVE CHARACTERS

3.3.1.1. Plant height

The height of the plant from the cotyledonary node to the tip of the plant was measured at the time of final harvest and expressed in centimetre.

3.3.1.2. Days to 50 per cent flowering

The number of days taken for flowering of 50 per cent population was counted and expressed in days.

3.3.1.3. Flower clusters per plant

All the flower clusters in a plant were counted up to final harvest.

3.3.1.4. Flowers per cluster

Total number of flowers per cluster was counted in all the clusters and average was calculated.

3.3.1.5. Fruit setting percentage

The fruit setting percentage was computed by the following formula (Villareal and Lal, 1979).

$$\text{Fruit setting percentage} = \frac{\text{Number of fruits per plant}}{\text{Number of flowers per plant}} \times 100$$

3.3.1.6. Fruiting clusters per plant

Total number of fruiting clusters per plant was counted from first to last picking and expressed in number.

3.3.1.7. Fruits per cluster

Total number of fruits in each cluster was counted in all the clusters and average was calculated.

3.3.1.8. Single fruit weight

Five ripe fruits were randomly selected from each replication, weighed and the mean was calculated and expressed in gramme.

3.3.1.9. Polar diameter

The five randomly selected fruits were cut longitudinally. The diameter was measured at the maximum point and the mean was expressed in centimetre.

3.3.1.10. Equatorial diameter

The five randomly selected fruits were cut transversely to measure the diameter at the maximum point. The mean was calculated and expressed in centimetre.

3.3.1.11. Yield per plant

The weight of all fruits harvested in a plant was measured and expressed in kilogramme.

3.3.1.12. Yield per hectare

Yield per plant was calculated and extrapolated to yield per hectare.

3.3.1.13. Fruit firmness

Firmness of the fruit was assessed with a penetrometer and expressed as kg cm^{-2}.

3.3.2. Biochemical characters

3.3.2.1. Total soluble solids (TSS)

The total soluble solids of the five randomly selected fruits were estimated using Zeiss hand refractometer and the mean was expressed in degree brix.

3.3.2.2 Acidity

The titrable acidity in tomato fruits was estimated by following the method of AOAC (1975) and expressed in per cent.

3.3.2.3. Ascorbic acid

Ascorbic acid content of the fruit was estimated by following the method of AOAC (1975) and expressed as mg 100 g^{-1} fresh flesh.

3.3.2.4. Total sugars

The total sugars were estimated as per the procedure given by Somoigyi (1952) and expressed in per cent.

3.3.3. Physiological characters

3.3.3.1. Specific leaf area (SLA)

Specific leaf area is a measure of the leafiness of the plant on a dry weight basis. It was arrived at by using the following formula and expressed as ($cm^2\ g^{-1}$).

$$SLA = \frac{\text{Leaf area}}{\text{Leaf dry weight}}$$

3.3.3.2. Specific leaf weight (SLW)

Specific leaf weight was arrived at by using the formula suggested by Pearce et al. (1968) and expressed in g cm^{-2}.

$$SLW = \frac{\text{Leaf weight}}{\text{Leaf area}}$$

3.3.3.3. Leaf area per plant

Leaves of five plants in a row from each replication were removed and their leaf area was measured using the Licor Model 3100 Leaf Area Meter. The mean of five plants was expressed in m^2.

3.3.3.4 Leaf area index (LAI)

LAI was calculated by employing the formula suggested by Williams (1946)

$$LAI = \frac{A}{L}$$

where A = Leaf area per plant
L = Area occupied by plant

3.3.3.5. Crop growth rate (CGR)

Crop growth rate represents total dry matter productivity of the plant community per unit area over certain time span. Crop growth at any time can be determined by measuring the plant dry weight at regular intervals of time divided by land area. It is expressed in g m^{-2} day^{-1} (Watson, 1958).

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where W_1 and W_2 are plant dry weights at times t_1 and t_2

P = spacing (m^2)

3.3.3.6 Net assimilation rate (NAR)

Net assimilation rate is defined as the increase in plant dry weight per unit of assimilatory surface per unit time. NAR was determined utilizing the formula proposed by Williams (1946). It is calculated on leaf area basis and expressed as g m^{-2} day^{-1}.

$$NAR = \frac{W_2 - W_1\,(\log_e A_2 - \log_e A_1)}{(t_2 - t_1)\,(A_2 - A_1)}$$

Where W_1 and W_2 are the plant dry weights at time t_1 and t_2 respectively

A_1 and A_2 are the leaf area at times t_1 and t_2 respectively.

3.3.3.7 Relative water content (RWC)

Relative water content was estimated by the method of Barrs and Weatherly (1962). Turgid weight was determined by cutting the fully expanded young leaf into bits and soaking in petri dish containing water for four hours.

$$\text{Relative water content (R.W.C)} = \frac{\text{Fresh weight- Dry weight}}{\text{Turgid weight-Dry weight}} \times 100$$

3.3.4. Media and plant nutrient analysis

3.3.4.1. Media nutrient analysis

The media samples were collected from different treatment plots at the time of harvest. Samples were collected at depth of 15 cm from different locations from all plots and were shade dried, ground with wooden mallets and passed through 2 mm sieve and bagged in cloth bag and used for analysis of N, P and K.

3.3.4.1.1. Available nitrogen

The available nitrogen content of medium was estimated by alkaline permanganate method (Subbiah and Asija, 1956) and expressed in Kg ha^{-1}.

3.3.4.1.2. Available phosphorus

The available P content of medium was estimated by the extraction with sodium bicarbonate (Olsen et al., 1954) and expressed in Kg ha^{-1}.

3.3.4.1.3. Available potassium

Available potassium content of medium was extracted with neutral normal ammonium acetate and estimated by the flame photometer and expressed in Kg ha^{-1} (Standford and English, 1949).

3.3.4.2. Leaf nutrient analysis

Fully expanded 5^{th} leaf from the top of the shoot was selected for sampling. Leaves were thoroughly washed with 0.1 N HCl followed by double distilled water. The plant samples were shade dried and then dried in hot air oven at 60^{0} C. The dried leaves were chopped with stainless steel knife and then used for analysis.

3.3.4.2.1. Plant nitrogen content

The nitrogen content of the leaf sample was estimated by microkjeldahl method (Humphries, 1956) and expressed in per cent.

3.3.4.2.2. Plant phosphorus content

The Phosphorus content of leaf was estimated by adopting vanado phosphoric yellow colour method (Jackson, 1973) and expressed in per cent.

3.3.4.2.3. Plant potassium content

Potassium content of the leaf sample was estimated by flame photometer method (Jackson 1973) and expressed in per cent.

3.3.5. Statistical analysis

The statistical analysis of the observations recorded was done according to the method suggested by Panse and Sukatme (1978).

3.3.5.1. Unit analysis

The statistical parameters like mean, standard error and coefficient of variation were calculated for all the characters by the standard method of analysis (Panse and Sukatme, 1978).

3.3.5.2. Simple correlation coefficient.

Analysis of covariance was done similar to that of analysis of variance, taking two characters at a time. These were carried out with all possible combinations and the mean sum of products for treatments replications and error were worked out.

Experimental Results

CHAPTER IV

RESULTS

The results of the greenhouse experiments conducted at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2000-2002 in two seasons (kharif and summer) on the effect of different media, different levels of fertigation with water soluble and insoluble fertilizers, and biofertilizers, two levels of irrigation, mulching, top dressing of fertilizer and spacing on growth and yield of hybrid tomato (*Lycopersicon esculentum* L.) SH 7611, compared with standard hybrid Arka Abijith are presented in this chapter.

The results are discussed in the order of growing media, irrigation regime, straight fertilizer, mulching, top dressing of fertilizer and spacing comparisons.

4.1 Quantitative characters

4.1.1. Plant height

The data on the plant height of tomato hybrids as influenced by different treatments for two seasons are presented in Table 2.

The height of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments, plant height varied from 250.2 cm in T_5 (with irrigation regime of 40 Kpa) to 292.3 cm in T_{12} (with spacing 30×22.5cm).

Among the growing media comparisons, T_3 with growing medium of Soil-Compost-Coco peat in the ratio 2:1:1, recorded the highest plant height (263.6 cm) followed by T_2 (263.1cm) with Soil-Compost-Sawdust in the ratio 2:1:1, T_1 (260.47cm) with soil-compost-sand in the ratio 2:1:1 and T_4 (260.2 cm) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa recorded the least plant height (250.2 cm) among all the treatments and it was considerably lower than control (T_1).

The treatment T_{10}, with biofertilizers and NPK fertilizers as basal, obtained a higher plant height (278.8cm) than T_6 (276.1cm) with biofertilizers and K fertilizer as basal.

The treatment T_7 (Fertigation with straight fertilizers) obtained a high plant height (272.1 cm) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a high plant height (266.63 cm) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a significantly higher plant height (267.63 cm) compared to control (T_1).

T_9 with standard hybrid Arka Abijith obtained a low plant height of 259.2 cm compared to control (T_1).

In kharif season also similar trend has been observed. The highest plant height was recorded for T_{12} (294.1 cm) and least for T_5 (253.1 cm). Among the growing media treatments, highest plant height was recorded in T_3 (265.68 cm) followed by T_2 (265.12 cm), T_4 (261.74 cm) and T_1 (261.62 cm). T_5 with irrigation regime 40 kpa recorded the lowest plant height (253.1 cm).

Table 2. Mean performance of hybrids for plant height (cm) and days to 50 per cent flowering.

Treatments	Plant height (cm)			Days to 50 per cent flowering		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	260.47	261.62	261.05	40.66	45.62	43.14
T2	263.10	265.12	264.11	41.33	46.64	43.99
T3	263.60	265.68	264.64	41.66	46.72	44.19
T4	260.20	261.74	260.97	42.00	47.12	44.56
T5	250.20	253.10	251.65	36.11	40.82	38.47
T6	276.10	278.20	277.15	39.33	44.84	42.09
T7	272.10	274.14	273.12	36.72	41.23	38.98
T8	267.63	269.68	268.65	37.32	43.14	40.23
T9	259.20	260.40	259.80	42.82	47.18	45
T10	278.80	280.24	279.52	39.63	44.92	42.28
T11	266.63	268.64	267.63	36.08	41.67	38.88
T12	292.30	294.36	294.33	35.18	38.12	36.65
Mean	267.53	269.41	268.47	38.98	45.45	42.21
S.Ed	1.1757	1.1868	1.1782	1.4349	1.6896	1.5642
C.D (0.05)	2.4382	2.6278	2.5231	2.9758	3.0231	3.0013
C.D (0.01)	3.3140	3.4321	3.3564	4.0447	4.1213	4.1614

Among the treatments with biofertilizer + NPK and K fertlizer applications, higher plant height was recorded in T_{10} (280.24 cm) than T_6 (278.2 cm). T_7 reported a higher plant height (274.14 cm) than control (T_1). T_{11} recorded a plant height of 270.13 cm. T_8 has reported a plant height of 283.6 cm. T_9 has recorded 266.1 cm as plant height in kharif.

Among all the treatments, the mean plant height of the hybrids for both the seasons was maximum in T_{12} (294.33 cm) and minimum in T_5 (251.65 cm).

4.1.2. Days to 50 per cent flowering

The data on the days to 50 per cent flowering of tomato hybrids as influenced by different treatments for two seasons are presented in table 2.

The observations on days to 50 per cent flowering of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments days to 50 per cent flowering varied from 35.18 days in T_{12}, (with spacing 30×22.5cm) to 42.82 days in T_9 (standard variety Arka Abijith).

Among growing media comparisons, T_1 with growing media of soil-compost-sand in the ratio 2:1:1 recorded a lower number of days to 50per cent flowering (40.66) followed by T_2 (41.33 days) with Soil-Compost-Sawdust in the ratio 2:1:1, T_3 (41.66) with Soil-Compost-Coco peat in the ratio 2:1:1 and T_4 (42.00) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 (with irrigation regime of 40 kpa) recorded a lower number of days taken for flowering (36.11days) than control.

The treatment T_{10} with biofertilizers and NPK fertilizers as basal recorded more days to 50 per cent flowering (39.63days) compared to T_6 (36.33 days) with biofertilizers and K fertilizer as basal.

The treatment T_7 (Fertigation with straight fertilizers) had taken less number of days to 50per cent flowering (36.72 days) compared to control.

The treatment T_{11} (with topdressing of NPK fertilizers) reported 36.08 as days to 50per cent flowering.

Among the mulching treatments, T_8 (37.32 days) without mulching recorded a lower number of days to 50 per cent flowering compared to control.

T_9 (with standard hybrid Arka Abijith) reported a late flowering for this character (42.82 days).

In kharif, hybrids had taken more number of days to 50 per cent flowering. Among the growing media treatments, earliest flowering was recorded in treatment T_1 (45.62 days) followed by T_2 (46.64 days), T_3 (46.72 days) and T_4 (47.12 days). T_5 with irrigation regime of 40 kpa recorded 40.82 as days to 50 per cent flowering.

Among the treatments with biofertilizer + NPK and K nutrient applications, number of days to 50 per cent flowering in T_6 was 44.84, which was on par with T_{10} (44.92 days).

T_7 has recorded the number of days to 50 per cent flowering as 41.23 and T_{11}, recorded 41.67 as days to 50 per cent flowering. T_8 has reported a lower number of days to 50 per cent flowering compared to control. The standard hybrid Arka Abijith reported 47.18 days and T_{12} had taken 38.12 days to 50 per cent flowering in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that days to 50 per cent flowering was maximum in T_9 (45 days) and minimum in T_{12} (36.65 days).

4.1.3. Flower clusters per plant

The data on the flower clusters per plant of tomato hybrids as influenced by different treatments for two seasons are presented in table 3.

The observations on flower clusters per plant of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, number of flower clusters per plant varied from 41 in T_{12}, (with spacing 30×22.5 cm) to 56.33 in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer +Azospirillum +PSB).

Among growing media comparisons, T_1 with growing media of soil-compost-sand in the ratio 2:1:1 obtained the highest number of flowering clusters per plant (52.33), followed by T_2 (51.33) with Soil-Compost-Sawdust in the ratio 2:1:1, T_3 (50.0) with Soil-Compost-Coco peat in the ratio 2:1:1, and T_4 (42.0) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower number of flower cluster (44.67) compared to control (T_1).

The treatment T_{10} with biofertilizers and NPK fertilizers as basal recorded a lower number of flower cluster (52.33) compared to T_6 (56.33) with biofertilizers and K fertilizer as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed lower number of flower cluster (44) compared to control.

The treatment T_{11} with top dressing of NPK fertilizers also recorded a lower number of flower cluster (45) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a lower number of flower cluster (41) compared to control (T_1).

T_9 with standard hybrid Arka Abijith reported less number of flower cluster per plant (44.33) compared to SH 7611.

In kharif season hybrids showed an enhancing trend in number of flower clusters. Among the growing media treatments, the highest number of flowering cluster has been recorded in T_1 (58.43) followed by T_2 (55.32), T_3 (54.16) and T_4 (52.02). T_5 has recorded a lower number of flower clusters (46.64) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, more number of flower clusters has been recorded in T_6 (62.14) compared to T_{10} (60.12). T_7 has recorded a lower number of flower clusters per plant (48.14) compared to control. T_8 also reported a lower number of flower clusters per plant (45.13) compared to T_1. T_{11} recorded 47.94 numbers of flowering clusters per plant. The standard hybrid Arka Abijith had 48.14 flower clusters per plant and T_{12} recorded 44.18 numbers of flower clusters per plant in kharif.

Among all the treatments, the mean performance of the hybrids for both seasons revealed that the number of flower clusters per plant was maximum in T_6 (59.23) and minimum in T_{12} (42.59).

Table 3. Mean performance of hybrids for number of flower clusters per plant and number of flowers per cluster

Treatments	Number of flower clusters per plant			Number of flowers per cluster		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	52.33	58.43	55.38	8.33	8.68	8.5
T2	50.33	55.32	52.82	7.00	7.82	7.41
T3	50.00	54.16	52.08	7.67	7.98	7.83
T4	42.00	52.02	47.01	6.67	7.12	6.89
T5	44.66	46.64	45.4	6.00	6.06	6.03
T6	56.33	62.14	59.23	10.33	10.38	10.35
T7	44.00	48.14	46.07	6.00	6.15	6.08
T8	41.00	45.13	43.06	6.00	6.22	6.11
T9	44.33	48.14	46.23	7.33	7.34	7.35
T10	52.33	60.12	56.13	9.67	10.12	9.95
T11	45.00	47.12	46.06	6.00	6.12	6.06
T12	41.00	44.18	42.59	5.33	5.42	5.38
Mean	46.89	51.58	49.23	7.19	7.45	7.32
S.Ed	0.8247	0.9862	0.9236	0.7023	0.8937	0.7582
C.D (0.05)	1.7103	1.8282	1.7862	1.4565	1.6283	1.5263
C.D (0.01)	2.3247	2.6872	2.4863	1.9798	2.0112	2.0116

4.1.4. Flowers per cluster

The data on the flowers per cluster of tomato hybrids as influenced by different treatments for two seasons are presented in table 3.

The observations on flowers per cluster of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments, number of flowers per cluster varied from 5.33 in T_{12}, (with spacing 30×22.5 cm) to 10.33 in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer +Azospirillum +PSB).

Among growing media comparisons, T_1 with growing media of soil-compost-sand in the ratio 2:1:1 obtained the highest number of flowers per cluster (8.33), followed by T_3 (7.67) with Soil-Compost-Coco peat in the ratio 2:1:1, T_2 (7.00) with Soil-Compost-Sawdust in the ratio 2:1:1, and T_4 (6.67) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower number of flowers per cluster (6.00) compared to control (T_1).

The treatment T_6 with biofertilizers and K fertilizer as basal recorded the highest number of flowers per cluster (10.33) and was on par with T_{10} (9.67) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 (fertigation with straight fertilizers) showed lower number of flowers per cluster (6.00) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower number of flowers per cluster (6.00) compared to control.

Among the mulching treatments, T_8 (6.00) without mulching recorded lower number of flowers per cluster compared to control.

T_9 with standard hybrid Arka Abijith reported less number of flowers per cluster (7.33) compared to SH 7611.

In kharif season hybrids performed comparatively well in number of flowers per cluster, compared to summer season. Among the growing media treatments, the highest number of flowers per cluster has been recorded in T_1 (8.68) followed by T_3 (7.98), T_2 (7.82) and T_4 (7.12). The T_5 has recorded a lower number of flowers per cluster (6.06) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, more number of flowers per clusters has been recorded in T_6 (10.38) compared to T_{10} (10.12). T_7 has recorded a lower number of flowers per cluster (6.15) compared to control. T_8 also reported a lower number of flowers per cluster (6.22) compared to T_1. T_{11} recorded 6.12 number of flowers per cluster. The standard hybrid Arka Abijith had 7.34 flowers per cluster and T_{12} recorded 5.42 number of flowers per cluster in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the flowers per cluster was maximum in T_6 (10.35) and minimum in T_{12} (5.38).

4.1.5. Fruit setting percentage

The data on the fruit setting percentage of tomato hybrids as influenced by different treatments for two seasons are presented in table 4.

The observations on fruit setting percentage of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments fruit setting percentage varied from 51.22 per cent in T_{12}, (with spacing 30×22.5 cm), to 67.23 per cent in T_1 (with growing media of Soil- Compost-Sand in the ratio of 2:1:1).

Among growing media comparisons, T_1 with growing media of soil-compost-sand in the ratio 2:1:1 obtained the highest fruit setting percentage (67.23 per cent), followed by T_3 (59.92 per cent) with growing media of Soil-Compost-Coco peat in the ratio 2:1:1, T_4 (59.68 per cent) with Soil-Compost-Paddy husk in the ratio 2:1:1, and T_2 (56.57 per cent) with Soil-Compost-Sawdust in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower fruit setting percentage (52.63 per cent) compared to control (T_1).

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded a higher fruit setting percentage of 66.68 per cent compared to T_{10} (65.23 per cent) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 (with straight fertilizer fertigation) showed lower fruit setting percentage of 59.98 compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower fruit setting percentage of 52.34 per cent compared to T_1.

Among the mulching treatments, T_8 (65.93 per cent) without mulching recorded a lower fruit setting percentage compared to control.

Table 4. Mean performance of hybrids for fruit setting percentage and number of fruiting clusters per plant.

Treatments	Fruit setting percentage			Number of fruiting clusters per plant		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	67.23	68.24	67.74	20.00	22.68	21.34
T2	56.67	60.62	58.65	22.00	24.13	23.07
T3	59.92	64.18	62.05	23.33	24.68	24.00
T4	59.68	62.17	60.92	17.67	18.23	17.95
T5	52.63	53.18	52.91	16.00	17.15	16.58
T6	66.68	68.12	67.40	23.67	25.68	23.68
T7	59.98	62.23	61.12	17.00	18.14	17.58
T8	65.93	66.14	66.04	18.00	19.27	18.64
T9	65.68	67.82	66.75	21.00	22.68	21.85
T10	65.23	67.42	66.32	23.00	25.48	24.24
T11	52.34	55.62	53.98	19.00	20.18	19.59
T12	51.22	52.14	51.68	14.00	15.62	14.81
Mean	60.26	62.32	61.25	16.94	19.75	18.34
S.Ed	1.1218	1.1423	1.1632	1.1757	1.2134	1.1965
C.D (0.05)	2.3265	2.4231	2.4132	2.4382	2.4467	2.4223
C.D (0.01)	3.1622	3.1867	3.1723	3.3140	3.4123	3.3562

T_9 with standard hybrid Arka Abijith reported a fruit setting percentage of 65.68 per cent.

In kharif season hybrids performed comparatively well in fruit setting percentage, and showed similar trend as in summer. The highest fruit setting percentage has been reported in T_1 (68.24 per cent) and the lowest fruit setting percentage has been recorded in T_{12} (52.14 per cent). Among the growing media treatments, the highest fruit setting percentage has been recorded in treatment T_1 (68.24 per cent) followed by T_3 (64.18 per cent), T_4 (62.17 per cent) and T_2 (60.62 per cent). T_5 has recorded a lower fruit setting percentage (53.18 per cent) compared to control.

Among the treatments with biofertilizer + NPK and K nutrient applications, a high fruit setting percentage has been recorded in T_6 (68.12 per cent) compared to T_{10} (67.82 per cent). T_7 has recorded a lower fruit setting percentage (62.23 per cent) compared to control. T_8 has reported a fruit setting percentage of 66.14 per cent. T_{11} recorded a low fruit setting percentage (55.62 per cent) compared to control. The standard hybrid Arka Abijith has reported a fruit setting percentage of 67.82 per cent. in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the fruit setting percentage was maximum in T_1 (67.74 per cent) and minimum in T_{12} (51.68 per cent).

4.1.6. Fruiting clusters per plant

The data on the number of fruiting cluster per plant of tomato hybrids as influenced by different treatments for two seasons are presented in table 4.

The observations on number of fruiting cluster per plant of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments number of fruiting cluster per plant varied from 14 in T_{12}, (With spacing 30×22.5 cm) to 23.67 in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer +Azospirillum +PSB).

Among growing media comparisons, T_3 with growing media of Soil-Compost-Coco peat in the ratio 2:1:1, obtained the highest number of fruiting clusters per plant (23.33), followed by T_2 (22.00) with Soil-Compost-Sawdust in the ratio 2:1:1, T_1 (20.00) with Soil- Compost- Sand in the ratio of 2:1:1, and T_4 (17.67) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower number of fruiting cluster per plant (16.00) compared to control (T_1).

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded the number of fruiting clusters per plant as 23.67, which was on par with T_{10} (23.00) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 (Fertigation with straight fertilizers) showed lower number of fruiting clusters per plant (17.00) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower number of fruiting clusters per plant (19.00) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a lower number of fruiting clusters per plant (18.00) compared to control (T_1).

T_9 with standard hybrid Arka Abijith reported 21 fruiting clusters per plant.

In kharif season hybrids performed comparatively well in terms of number of fruiting clusters per plant and showed almost similar trend except for some treatments as in summer. The highest number of fruiting clusters per plant has been reported in T_6 (25.68) and the lowest has been recorded in T_{12} (15.62). Among the growing media treatments, the highest number of fruiting clusters per plant has been recorded in treatment T_3 (24.68) followed by T_2 (24.13), T_1 (22.68) and T_4 (18.23). T_5 has recorded a lower number of fruiting clusters per plant (17.15) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, more number of fruiting clusters per plant has been recorded in T_6 (25.68) compared to T_{10} (25.48). T_7 has recorded lower number of fruiting clusters per plant (18.14) compared to control. T8 has also reported a lower number of fruiting clusters per plant (19.27) compared to T_1. T_{11} recorded fruiting clusters per plant as 20.18. The standard hybrid Arka Abijith had recorded 22.68 fruiting clusters per plant in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the number of fruiting clusters per plant was maximum in T_{10} (24.24) and minimum in T_{12} (14.81).

4.1.7. Fruits per cluster

The data on the number of fruits per cluster of tomato hybrids as influenced by different treatments for two seasons are presented in table 5.

The observations on number of fruits per cluster of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments number of fruits per cluster varied from 2.67 in T_{12} (with spacing 30×22.5 cm), which was on par with T_5 (2.67) (with irrigation regime of 40 kpa), to 5.33 in T_6 (with Basal 50 kg ha^{-1} K with straight fertilizer +Azospirillum +PSB.

Among growing media comparisons, T_1 (5.00) with growing media of Soil-Compost-Sand in the ratio 2:1:1 obtained the highest number of fruits per cluster followed by T_3 (3.67) with of Soil-Compost-Coco peat in the ratio 2:1:1, T_2 (3.33) with Soil-Compost-Sawdust in the ratio 2:1:1 and T_4 (3.33) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower number of fruits per cluster (2.67) compared to control (T_1).

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded the number of fruits per cluster as 5.33, which was on par with T_{10} (5.00) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 (with straight fertilizer fertigation) showed lower number of fruits per cluster (3.33) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower number of fruits per cluster (3.00) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a lower fruiting cluster per plant (3.00) compared to control (T_1).

T_9 with standard hybrid Arka Abijith reported 4 fruits per cluster.

In kharif season hybrids performed well in terms of number of fruits per cluster and showed almost similar trend except for some treatments compared to summer. The highest number of fruits per cluster has been reported in T_6

Table 5. Mean performance of hybrids for number of fruits per cluster and single fruit weight (g).

Treatments	Number of fruits per cluster			Single fruit weight (g)		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	5.00	6.18	5.59	72.18	75.23	73.71
T2	3.33	4.50	3.92	66.34	69.38	67.86
T3	3.67	4.80	4.24	68.21	72.14	70.18
T4	3.33	4.20	3.77	65.98	68.13	67.06
T5	2.67	3.12	2.89	62.12	65.14	63.63
T6	5.33	6.50	5.92	79.56	83.44	81.50
T7	3.33	4.18	3.76	66.26	69.28	67.77
T8	3.00	4.10	3.55	69.40	72.11	70.75
T9	4.00	4.98	4.49	68.23	71.26	69.75
T10	5.00	6.12	5.56	82.10	85.14	83.62
T11	3.00	3.44	3.22	51.87	55.18	53.52
T12	2.67	2.98	2.83	50.20	54.12	52.16
Mean	3.69	4.59	4.12	66.80	70.04	68.42
S.Ed	0.6343	0.7453	0.6842	1.8020	1.9654	1.8563
C.D (0.05).	1.3155	1.3456	1.3265	3.7372	3.8453	3.7825
C.D (0.01)	1.7880	1.8675	1.8214	5.0796	5.1345	5.1020

(6.5) and the lowest in T_{12} (2.98). Among the growing media treatments, the highest number of fruits per cluster has been recorded in T_1 (6.18) followed by T_3 (4.8), T_2 (4.5) and T_4 (4.2). T_5 has recorded a lower number of fruits per cluster (3.12) compared to control.

Among the treatments with biofertilizer + NPK and K nutrient applications, more number of fruits per cluster has been recorded in T_6 (6.5) compared to T_{10} (6.12). T_7 with straight fertilizer fertigation has recorded a lower number of fruits per cluster (4.18) compared to control. T_8 has also reported a lower number of fruits per cluster (5.15) compared to T_1. T_{11} recorded a lower number of fruits per cluster (5.20) compared to T_1. The standard hybrid Arka Abijith had 6.55 fruits per cluster in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the number of fruits per cluster was maximum in T_6 (5.92) and minimum in T_{12} (2.83).

4.1.8. Single fruit weight

The data on the single fruit weight of tomato hybrids as influenced by different treatments for two seasons are presented in table 5.

The observations on single fruit weight of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments single fruit weight varied from 50.2 g in T_{12}, (with spacing 30×22.5 cm) to 82.1 g in T_{10} (with basal 50 kg ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_1 with growing media of soil-compost-sand in the ratio 2:1:1 obtained the highest single fruit weight (72.18 g), followed by T_3 (68.21 g) with Soil-Compost-Coco peat in the ratio 2:1:1, T_2 (66.34 g) with Soil-Compost-Sawdust in the ratio 2:1:1 and T_4 (65.98 g) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 (with irrigation regime of 40 kpa) reported a lower fruit weight of 62.12 g compared to control (T_1).

The treatment T_{10} with biofertilizers and NPK fertilizers as basal recorded a higher fruit weight (82.1 g), which was on par with T_6 (79.56 g) with biofertilizers and K fertilizer as basal.

The treatment T_7 (with fertigation with straight fertilizers) showed lower fruit weight (66.26 g) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower fruit weight (51.87 g) compared to control.

Among the mulching treatments, T_8 (69.4 g) without mulching recorded a lower fruit weight compared to control.

T_9 with standard hybrid Arka Abijith reported a single fruit weight of 68.23 g.

In kharif season hybrids performed well interms of single fruit weight compared to summer and showed similar trends. Among the growing media treatments, highest single fruit weight has been recorded in treatment T_1 (75.23 g) followed by T_3 (72.14 g), T_2 (69.38 g) and T_4 (68.13 g). T_5 with irrigation regime of 40 kpa has reported a single fruit weight of 65.14 g in kharif.

Among the treatments with biofertilizer + NPK and K nutrient applications, the highest fruit weight was recorded in T_6 (83.44 g), which was on par with T_{10} (85.14 g). T_7 has recorded a lower fruit weight (69.28 g) compared to control. T_8 has reported a single fruit weight of 72.11 g. T_{11} recorded a lower fruit weight of 55.18 g compared to control. The standard hybrid Arka Abijith reported a fruit weight of 71.26 g in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the single fruit weight was maximum in T_{10} (83.62 g) and minimum in T_{12} (52.16 g).

4.1.9. Polar diameter

The data on the polar diameter of fruits of tomato hybrids as influenced by different treatments for two seasons are presented in table 6.

The observations on polar diameter of fruits of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments polar diameter of fruits varied from 7.25 cm in T_{12} (with spacing 30×22.5 cm) to 8.75 cm in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB.)

Among growing media comparisons, T_1 (8.52 cm) with growing media of Soil-Compost-Sand in the ratio 2:1:1 obtained the highest polar diameter of fruits followed by T_3 (8.35 cm) with of Soil-Compost-Coco peat in the ratio of 2:1:1, T_4 (3.33) with Soil-Compost-Paddy husk in the ratio 2:1:1 and T_2 (7.90 cm) with Soil-Compost-Sawdust in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower polar diameter of fruits (7.55 cm) compared to control.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded the highest polar diameter of fruits (8.75 cm), which was on par with T_{10} (8.55 cm) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed lower polar diameter of fruits (7.80 cm) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower polar diameter of fruits (8.00 cm) compared to T_1.

Among the mulching treatments, T_8 (7.75 cm) without mulching recorded lower polar diameter of fruits compared to control.

T_9 with standard hybrid Arka Abijith reported 8.02 cm of fruit polar diameter.

In kharif season, hybrid's performance was similar to summer in terms of polar diameter of fruits except for some treatments. The highest polar diameter of fruits has been reported in T_6 (8.82 cm) and the lowest in T_{12} (7.29 cm). Among the growing media treatments, the highest polar diameter of fruits has been recorded in T_1 (8.68 cm) followed by T_3 (8.48 cm), T_4 (8.32 cm) and T_2 (7.94 cm). T_5 has recorded a lower polar diameter of fruits (7.62 cm) compared to control (T_1).

Among the treatments with biofertilizer + NPK and K nutrient applications, a high polar diameter of fruits has been recorded in T_6 (8.82 cm) compared to T_{10} (8.64 cm). T_7 has recorded a low polar diameter of fruits (7.82 cm) compared to T_1. T_8 without mulching has also reported a low fruit polar diameter (7.86 cm) compared to control. T_{11} recorded lower fruit polar diameter (8.08 cm) compared to T_1. The standard hybrid Arka Abijith had 8.10 cm fruit polar diameter in kharif.

Table 6. Mean performance of hybrids for polar diameter (cm) and equatorial diameter (cm) of the fruit.

Treatments	Polar diameter (cm)			Equatorial diameter (cm)			Polar-equatorial diameter ratio
	Summer	Kharif	Mean	Summer	Kharif	Mean	Mean
T1	8.52	8.68	8.60	8.25	8.28	8.27	1.04
T2	7.90	7.94	7.92	7.25	7.30	7.28	1.08
T3	8.35	8.48	8.58	8.04	8.16	8.1	1.02
T4	8.29	8.32	8.31	8.05	8.10	8.08	1.05
T5	7.55	7.62	7.59	7.02	7.06	7.04	1.07
T6	8.75	8.82	8.79	8.25	8.29	8.27	1.06
T7	7.80	7.82	7.81	7.55	7.59	7.57	1.03
T8	7.75	7.86	7.81	7.52	7.52	7.52	1.03
T9	8.03	8.10	8.07	8.12	8.22	8.17	0.92
T10	8.55	8.64	8.59	8.75	8.82	8.79	1.02
T11	8.00	8.08	8.04	8.00	8.04	8.2	1.01
T12	7.29	7.29	7.29	7.75	7.84	7.79	1.06
Mean	8.06	8.14	8.10	7.89	7.93	7.91	0.95
S.Ed	0.1064	0.1086	0.1078	0.2490	0.2865	0.2645	0.0124
C.D (0.05)	0.2206	0.2345	0.2145	0.5163	0.5345	0.5213	0.1867
C.D (0.01)	0.2999	0.3110	0.3010	0.7018	0.8123	0.7519	0.3568

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the polar diameter of the fruit was maximum in T_6 (8.79 cm) and minimum in T_{12} (7.29 cm).

4.1.10. Equatorial diameter

The data on the equatorial diameter of fruits of tomato hybrids as influenced by different treatments for two seasons are presented in table 6.

The observations on equatorial diameter of fruits of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments equatorial diameter of fruits varied from 7.02 cm in T_5 (with Irrigation regime of 40 Kpa) to 8.75 cm in T_{10} (with basal 50 kg ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_1 (8.25 cm) with growing media of Soil-Compost-Sand in the ratio 2:1:1 obtained the highest equatorial diameter of fruits followed by T_4 (8.05 cm) with Soil-Compost-Paddy husk in the ratio 2:1:1, T_3 (8.04 cm) with of Soil-Compost-Coco peat in the ratio of 2:1:1 and T_2 (7.25 cm) with Soil-Compost-Sawdust in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower equatorial diameter of fruits (7.02 cm) compared to control (T_1).

The treatment T_{10} with biofertilizers and NPK fertilizer as basal has recorded the highest equatorial diameter of fruits (8.75 cm), which was on par with T_6 (8.25 cm) with biofertilizers and K fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed lower equatorial diameter of fruits (7.55 cm) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a low equatorial diameter of fruits (8.00 cm) compared to control.

Among the mulching treatments, T_8 (7.52 cm) without mulching recorded a low equatorial diameter of fruits compared to control.

T_9 with standard hybrid Arka Abijith reported 8.02 cm of fruit equatorial diameter.

In kharif season, hybrid's performance was very similar to summer in terms of equatorial diameter of fruits. The highest equatorial diameter of fruits has been reported in T_{10} (8.82 cm) and the lowest in T_5 (7.06 cm). Among the growing media treatments, the highest equatorial diameter of fruits has been recorded in treatment T_1 (8.28 cm) that is followed by T_4 (8.10 cm), T_3 (8.16 cm) and T_2 (7.30 cm). T_5 has recorded the lowest equatorial diameter of fruits (7.06 cm) compared to control (T_1).

Among the treatments with biofertilizer + NPK and K nutrient applications, higher equatorial diameter of fruits have been recorded in T_{10} (8.82 cm) compared to T_6 (8.29 cm). T_7 with straight fertilizer fertigation has recorded a lower equatrial diameter of fruits (7.59 cm) compared to control. T_8 has also reported a lower equatorial diameter of fruits (7.52 cm) compared to control. T_{11} recorded a lower equatorial diameter of fruits (8.08 cm) compared to T_1. The standard hybrid Arka Abijith had 8.10 cm fruit equatorial diameter in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the equatorial diameter of the fruit was maximum in T_{10} (8.79 cm) and minimum in T_{12} (7.79 cm).

4.1.11. Yield per plant

The data on the yield per plant of tomato hybrids as influenced by different treatments for two seasons are presented in table 7.

The observations on yield per plant of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, yield per plant varied from 2.20 kg in T_{12} (with spacing 30×22.5 cm) to 4.85 kg in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum +PSB).

Among growing media comparisons, T_1 (4.40 kg) with growing media of Soil-Compost-Sand in the ratio 2:1:1 obtained the highest yield per plant followed by T_3 (4.35 kg) with Soil-Compost-Coco peat in the ratio 2:1:1, which was on par with T_2 (4.20 kg) with Soil-Compost-Sawdust in the ratio 2:1:1 and T_4 (4.10 kg) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower yield per plant (3.90 kg) compared to control.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded the highest yield per plant (4.85 kg) and was greater than T_{10} (4.6 kg) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed lower yield per plant (3.80 kg) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower yield per plant (3.65 kg) compared to control.

Among the mulching treatments, T_8 (3.52 kg) without mulching recorded a lower yield per plant compared to T_1.

T_9 with standard hybrid Arka Abijith reported 4.15 kg yield per plant.

In kharif season, hybrid's performance was better compared to summer in terms of yield per plant. The highest yield per plant has been reported in T_6 (6.10 kg) and the lowest in T_{12} (2.8 kg). Among the growing media treatments, the highest yield per plant has been recorded in treatment T_1 (5.82 kg) that is followed by T_3 (5.72 kg), which was on par with T_2 (5.67 kg) followed by T_4 (5.45 kg). T_5 has recorded a lower yield per plant (4.51 kg) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, the highest yield per plant has been recorded in T_6 (6.10 kg) compared to all other treatments and was on par with T_{10} (6.00 kg). T_7 with straight fertilizer fertigation has recorded a lower yield per plant (5.28 kg) compared to control. T_8 has also reported a lower yield per plant (5.42 kg) compared to T_1. T_{11} recorded a lower yield per plant (4.52 kg) compared to control. The standard hybrid Arka Abijith had 5.55 kg total yield per plant in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the yield per plant was maximum in T_6 (5.48 kg) and minimum in T_{12} (2.50 kg).

Table 7. Mean performance of hybrids for yield per plant (kg) and yield per hectare (t).

Treatments	Yield per plant (kg)			Yield per hectare (t)		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	4.40	5.82	5.11	165.87	215.34	190.61
T2	4.20	5.67	4.94	156.19	209.79	182.99
T3	4.35	5.72	5.04	161.78	211.64	186.71
T4	4.10	5.45	4.78	152.48	201.65	177.07
T5	3.90	5.12	4.51	145.04	189.44	167.24
T6	4.85	6.10	5.48	177.84	225.70	201.77
T7	3.80	5.28	4.54	141.32	195.36	168.34
T8	3.52	5.42	4.47	130.90	200.54	165.72
T9	4.15	5.55	4.85	154.34	205.35	179.85
T10	4.60	6.00	5.3	171.07	222.00	196.54
T11	3.65	4.52	4.09	135.75	167.24	151.49
T12	2.20	2.80	2.5	163.99	207.20	185.59
Mean	4.06	5.28	4.67	154.71	195.36	175.04
S.Ed	0.0729	0.0821	0.0768	1.3179	1.4623	1.3682
C.D (0.05)	0.1511	0.1623	0.1562	2.7331	2.8243	2.7812
C.D (0.01)	0.2054	0.2086	0.2067	3.9932	4.0345	4.0121

4.1.12. Yield per hectare

The data on the yield per hectare (estimated) of tomato hybrids as influenced by different treatments for two seasons are presented in table 7.

The observations on yield per hectare of the hybrids showed a significant difference among the different treatments during both the experimental seasons

In summer, among the different treatments yield per hectare varied from 135.75 t ha^{-1} in T_{11} (with Top dressing of NPK in 5 splits and with mulching to 177.85 t ha^{-1} in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_1 (165.87 t ha^{-1}) with growing media of Soil-Compost-Sand in the ratio 2:1:1 obtained the highest yield per hectare followed by T_3 (161.78 t ha^{-1}) with of Soil-Compost-Coco peat in the ratio 2:1:1, T_2 (156.19 t ha^{-1}) with Soil-Compost-Sawdust in the ratio 2:1:1 and T_4 (152.48 t ha^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower yield per hectare (145.04 t ha^{-1}) compared to control.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded the highest yield per hectare (177.85 t ha^{-1}) and is greater than T_{10} (171.07 t ha^{-1}) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed lower yield per hectare (141.32 t ha^{-1}) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower yield per hectare (135.75 t ha^{-1}) compared to T_1.

Among the mulching treatments, T_8 (130.90 t ha^{-1}) without mulching recorded a lower yield per hectare compared to control.

T_9 with standard hybrid Arka Abijith reported 154.34 t yields per hectare.

In kharif season, hybrid's performance was better and the trend was similar compared to summer in terms of yield per hectare. The highest yield per hectare has been reported in T_6 (225.70 t ha^{-1}) and the lowest in T_{11} (167.24 t ha^{-1}). Among the growing media treatments, the highest yield per hectare has been recorded in treatment T_1 (215.34 t ha^{-1}) followed by T_3 (211.64 t ha^{-1}), T_2 (209.79 t ha^{-1}) and T_4 (201.65 t ha^{-1}). The treatment with irrigation regime 40 kpa, (T_5) has recorded a lower yield per hectare (189.44 t) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, the highest yield per hectare has been recorded in T_6 (225.70 t ha^{-1}) compared to all other treatments and was higher than T_{10} (222.00 t ha^{-1}). T_7 has recorded a lower yield per hectare (195.36 t ha^{-1}) compared to control. T_8 has also reported a lower yield per hectare (200.54 t ha^{-1}) compared to control. T_{11} recorded a lower yield per hectare (167.24 t ha^{-1}) compared to T_1. The standard hybrid Arka Abijith recorded 205.35 t yield per hectare in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the yield per hectare was maximum in T_6 (201.77 t ha^{-1}) and minimum in T_{11} (151.49 t).

4.1.13. Fruit firmness

The data on the fruit firmness of tomato hybrids as influenced by different treatments for two seasons are presented in table 8.

The observations on fruit firmness of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, fruit firmness varied from 0.38 kg cm^{-2} in T_4 (with growing media of Soil-Compost-Paddy husk in the ratio 2:1:1.) to 0.58 kg cm^{-2} in T_5 (Irrigation regime of 40 Kpa)

Among growing media comparisons, T_3 (0.42 kg cm^{-2}) with Soil-Compost-Coco peat in the ratio 2:1:1, obtained the highest fruit firmness followed by T_1 (0.40 kg cm^{-2}) with Soil-Compost-Paddy husk in the ratio of 2:1:1, T_2 (0.39 kg cm^{-2}) with Soil-Compost-Sawdust in the ratio 2:1:1, which was on par with T_4 (0.38 kg cm^{-2}) with Soil-Compost-Sand in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported highest fruit firmness (0.58 kg cm^{-2}) compared to control and all other treatments.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded a fruit firmness of 0.43 kg cm^{-2}, which was on par with T_{10} (0.41 kg cm^{-2}) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed higher fruit firmness (0.48 kg cm^{-2}) compared to control with water-soluble fertilizers.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a higher fruit firmness (0.46 kg cm^{-2}) compared to T_1.

Among the mulching treatments, T_8 (0.51 kg cm^{-2}) without mulching recorded higher fruit firmness compared to control (T_1).

Table 8. Mean performance of hybrids for fruit firmness (kg cm^{-2})

Treatments	Fruit firmness (kg cm^{-2})		
	Summer	Kharif	Mean
T1	0.40	0.41	0.41
T2	0.39	0.39	0.39
T3	0.42	0.42	0.42
T4	0.38	0.39	0.39
T5	0.58	0.56	0.57
T6	0.43	0.42	0.43
T7	0.48	0.48	0.48
T8	0.51	0.50	0.51
T9	0.41	0.42	0.41
T10	0.42	0.43	0.43
T11	0.46	0.48	0.47
T12	0.52	0.53	0.53
Mean	0.45	0.45	0.45
S.Ed	0.0211	0.0242	0.0235
C.D (0.05)	0.0438	0.0474	0.0446
C.D (0.01)	0.0595	0.0591	0.0593

T_9 with standard hybrid Arka Abijith reported 0.41 kg cm^{-2} and T_{12} recorded 0.52 kg cm^{-2} fruit firmness.

In kharif season, the fruit firmness of the hybrids showed a decreasing trend in general. The highest fruit firmness has been reported in T_5 (0.56 kg cm^{-2}) and the lowest in T_2 and T_4 (0.39 kg cm^{-2}). Among the growing media treatments, the highest fruit firmness has been recorded in treatment T_3 (0.42 kg cm^{-2}) followed by T_1 (0.41 kg cm^{-2}), T_2 (0.39 kg cm^{-2}) and T_4 (0.39 kg cm^{-2}). T_5 (0.45 kg cm^{-2}) has recorded the highest fruit firmness among all the treatments.

Among the treatments with biofertilizer + NPK and K nutrient applications, a higher fruit firmness has been recorded in T_{10} (0.43 kg cm^{-2}), which was on par with T_6 (0.42 kg cm^{-2}). T_7 has recorded a higher fruit firmness (0.48 kg cm^{-2}) compared to control. T_8 without mulching has also reported a higher fruit firmness (0.50 kg cm^{-2}) compared to T_1. T_{11} recorded a fruit firmness of 0.48 kg cm^{-2}. The standard hybrid Arka Abijith reported a fruit firmness of 0.42 kg cm^{-2} fruit firmness in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the fruit firmness was maximum in T_5 (0.53 kg cm^{-2}) and minimum in T_2 and T_4 (0.39 kg cm^{-2}).

4.2. Biochemical characters

4.2.1. Total soluble solids

The data on the total soluble solids content of fruits of tomato hybrids as influenced by different treatments for two seasons are presented in table 9.

The observations on total soluble solids content of fruits of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, total soluble solids of fruits varied from 3.1^0 brix in T_4 (with growing media of Soil-Compost-Sand in the ratio 2:1:1) and T_9 (with standard hybrid Arka Abijith) to 4.2^0 brix in T_5 (with irrigation regime of 40 Kpa).

Among growing media comparisons, T_2 (3.22^0 brix) with growing media of soil-compost-sawdust in the ratio 2:1:1 obtained the highest T.S.S which was on par with T_1 (3.2^0 brix) with of Soil-Compost-Sand in the ratio 2:1:1 followed by T_3 (3.18^0 brix) with Soil-Compost-Coco peat in the ratio 2:1:1 and T_4 (3.10^0 brix) with Soil-Compost-Paddy husk in the ratio of 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported the highest T.S.S (4.20^0 brix) compared to control and all other treatments.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded a T.S.S of 3.3^0 brix and was on par with T_{10} (3.32^0 brix) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers showed higher T.S.S (3.8^0 brix) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower T.S.S (3.12^0 brix) compared to control.

Among the mulching treatments, T_8 (3.6^0 brix) without mulching recorded a lower T.S.S compared to control.

T_9 with standard hybrid Arka Abijith reported 3.1^0 brix as fruit T.S.S.

Table 9. Mean performance of hybrids for total soluble solids (^{0} brix) and total sugars (per cent) of the fruit.

Treatments	Total soluble solids (^{0} brix)			Total sugars (per cent)		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	3.20	3.23	3.22	1.94	1.96	1.95
T2	3.22	3.22	3.22	1.92	1.92	1.92
T3	3.18	3.21	3.19	1.92	1.92	1.92
T4	3.10	3.16	3.13	1.89	1.90	1.90
T5	4.20	4.18	4.19	1.78	1.80	1.79
T6	3.30	3.38	3.34	1.94	1.94	1.94
T7	3.80	3.82	3.81	1.88	1.90	1.49
T8	3.60	3.64	3.62	1.92	1.92	1.92
T9	3.10	3.12	3.11	1.87	1.88	1.88
T10	3.32	3.36	3.34	1.92	1.93	1.92
T11	3.12	3.10	3.11	1.82	1.80	1.81
T12	3.58	3.52	3.55	1.70	1.72	1.71
Mean	3.40	3.42	3.41	1.87	1.88	1.87
S.Ed	0.1013	0.1016	0.1014	0.0471	0.0492	0.0482
C.D (0.05)	0.2100	0.2210	0.0216	0.0976	0.0994	0.0982
C.D (0.01)	0.2854	0.2941	0.2850	1.1327	1.1456	1.1382

In kharif season, hybrid's showed similar trend in T.S.S compared to summer. The highest T.S.S has been reported in T_5 (4.18° brix) and the lowest in T_{11} (3.10° brix), which was on par with T_9. Among the growing media treatments, the highest T.S.S has been recorded in treatment T_1 (3.23° brix), which was on par with T_2 (3.22° brix) and T_3 (3.21° brix) followed by T_4 (3.16° brix).

Among the treatments with biofertilizer + NPK and K nutrient applications, T_6 has recorded a fruit T.S.S of 3.38° brix, which was on par with T_{10} (3.36° brix). T_7 has recorded a higher T.S.S (3.82° brix) compared to control. T_8 has also reported a higher T.S.S (3.64° brix) compared to T_1. T_{11} recorded a lower T.S.S (3.10° brix) compared to T_1. The standard hybrid Arka Abijith recorded 3.12° brix as fruit T.S.S in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the T.S.S was maximum in T_5 (4.19° brix) and minimum in T_9 and T_{11} (3.11° brix).

4.2.2. Total sugars

The data on the total sugars of fruits of tomato hybrids as influenced by different treatments for two seasons are presented in table 9.

The observations on total sugars content of fruits of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments total sugars of fruits varied from 1.70 per cent in T_{12} (with spacing 30×22.5 cm) to 1.94 per cent in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_1 (1.94 per cent) with Soil-Compost-Sand in the ratio 2:1:1, obtained the highest total sugars content of fruit followed by T_2 (1.92 per cent) with Soil-Compost-Sawdust in the ratio 2:1:1, which was on par with T_3 (1.92 per cent) with Soil-Compost-Coco peat in the ratio 2:1:1, T_4 (3.16 per cent) (With growing media of Soil-Compost-Paddy husk in the ratio 2:1:1).

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower total sugars content of fruit (1.79 per cent) compared to control.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded a total sugars content of fruit (1.94 per cent) and was on par with T_{10} (1.92 per cent) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a total sugars content of 1.88 per cent.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower total sugars content (1.82 per cent) compared to control.

Among the mulching treatments, T_8 without mulching recorded a total sugars content of 1.92 per cent.

T_9 with standard hybrid Arka Abijith reported 1.87 per cent of total sugars content of fruits.

In kharif season, hybrids showed similar trend in total sugars content of fruits as in summer. The highest total sugars content of fruits has been reported in T_1 (1.96 per cent) and the lowest in T_{12} (1.72 per cent). Among the growing media treatments, the highest total sugars content of fruits has been recorded in treatment T_1 (1.96 per cent) followed by T_2 (1.92 per cent) and T_3

(1.92 per cent), which were on par with each other, followed by T_4 (1.90 per cent).

T_5 has recorded a lower total sugars content of fruit (1.80) compared to control. Among the treatments with biofertilizer + NPK and K nutrient applications, T_6 has recorded a higher total sugars content of fruit (1.94 per cent) and was on par with T_{10} (1.93 per cent). T_7 with straight fertilizer fertigation has recorded a total sugars content of fruit of 1.90 per cent. T_8 has reported a total sugars content of fruit of 1.92 per cent.

T_{11} recorded a lower total sugars content of fruit (1.80 per cent) compared to control. The standard hybrid Arka Abijith recorded 1.88 per cent as total fruit sugar content in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the total sugarss was maximum in T_1 (1.94 per cent) and minimum in T_{12} (1.71 per cent) taken both seasons together.

4.2.3.Ascorbic acid

The data on the ascorbic acid content of the fruits of tomato hybrids as influenced by different treatments for two seasons are presented in table 10.

The observations on ascorbic acid content of fruits of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments ascorbic acid content of the fruits varied from 20.20 mg $100g^{-1}$ in T_{12} (spacing 30×22.5 cm) to 28.20 mg 100 g^{-1} in T_6 (basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_1 (26.10 mg 100 g^{-1}) with growing media of Soil-Compost-Sand in the ratio of 2:1:1, obtained the highest ascorbic acid content of the fruits followed by T_3 (24.33 mg 100 g^{-1}) with Soil-Compost-Coco peat in the ratio of 2:1:1, which was on par with T_2 (23.80 mg 100 g^{-1}) with Soil-Compost-Sawdust in the ratio 2:1:1 and T_4 (21.4 mg 100 g^{-1}) with Soil-Compost-Paddy husk in the ratio of 2:1:1.

The treatment T_5 with irrigation regime of 40 kpa reported lower ascorbic acid content of the fruits (22.60 mg 100 g^{-1}) compared to control.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded the highest ascorbic acid content of the fruits compared to all other treatments and T_{10} (26.70 mg 100 g^{-1}) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a lower ascorbic acid content 22.30 mg 100 g^{-1} compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower ascorbic acid content of the fruits (22.20 mg 100 g^{-1}) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a total ascorbic acid content of 23.60 mg 100 g^{-1}.

T_9 with standard hybrid Arka Abijith reported 24.80 mg 100 g^{-1} of ascorbic acid content of the fruits.

In kharif season, hybrids showed similar trend in ascorbic acid content of the fruits as in summer except for some treatments. The highest ascorbic acid content of the fruits has been reported in T_6 (28.68 mg 100 g^{-1}) and the lowest in T_{12} (20.42 mg 100 g^{-1}). Among the growing media treatments, the highest ascorbic acid content of the fruits has been recorded in treatment T_1 (26.22 mg 100 g^{-1}) followed by T_3 (25.23 mg 100 g^{-1}), which was on par with T_2

Table 10. Mean performance of hybrids for total acidity (per cent) and ascorbic acid content (mg 100 g^{-1}) of the fruit.

Treatments	Ascorbic acid content (mg 100 g^{-1})			Titrable acidity (per cent)		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	26.10	26.22	26.16	0.48	0.52	0.49
T2	23.80	24.84	24.32	0.38	0.41	0.39
T3	24.23	25.23	24.73	0.52	0.54	0.53
T4	21.40	21.44	21.42	0.46	0.48	0.47
T5	22.60	22.88	22.74	0.50	0.50	0.50
T6	28.20	28.68	28.44	0.54	0.56	0.55
T7	22.30	22.46	22.38	0.41	0.40	0.41
T8	23.60	23.67	23.64	0.46	0.48	0.47
T9	24.80	24.82	24.81	0.49	0.50	0.50
T10	26.70	27.12	26.91	0.52	0.54	0.53
T11	22.20	22.82	22.51	0.38	0.38	0.38
T12	20.20	20.42	20.31	0.42	0.44	0.43
Mean	23.84	24.22	24.03	0.46	0.47	0.47
S.Ed	0.4296	0.5621	0.4832	0.0129	0.0167	0.0148
C.D (0.05)	0.8909	0.9256	0.9012	0.0267	0.0282	0.0272
C.D (0.01)	1.2109	1.3421	1.2863	0.0363	0.0412	0.0388

(24.84 mg 100 g^{-1}) followed by T_4 (21.44 mg 100 g^{-1}). T_5 has recorded a lower ascorbic acid content of the fruits (22.88 mg 100 g^{-1}) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, higher ascorbic acid content of the fruits has been recorded in T_6 (28.68 mg 100g^{-1}) compared to T_{10} (27.12 mg 100 g^{-1}) and all other treatments. T_7 with straight fertilizer fertigation has recorded a lower ascorbic acid content of the fruits 22.46 mg 100 g^{-1} compared to control. T_8 without mulching has also reported a lower ascorbic acid content of the fruits (23.67 mg 100 g^{-1}) compared to T_1. T_{11} recorded one of the lowest ascorbic acid content of the fruits (22.82 mg 100 g^{-1}). The standard hybrid Arka Abijith recorded 24.82 mg 100 g^{-1} as ascorbic acid content of the fruits in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the ascorbic acid was maximum in T_6 (28.44 mg 100 g^{-1}) and minimum in T_{12} (20.20 mg 100 g^{-1}).

4.2.5. Titrable acidity

The data on the titrable acidity of the fruits of tomato hybrids as influenced by different treatments for two seasons are presented in table 10.

The observations on titrable acidity of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments titrable acidity of the fruits varied from 0.38 per cent in T_{11} (with top dressing of NPK in 5 splits) to 0.54 per cent in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_3 (0.52 per cent) with Soil-Compost-Coco peat in the ratio 2:1:1, obtained the highest titrable acidity of the fruits followed by T_1 (0.48 per cent) with Soil-Compost-Sand in the ratio 2:1:1, which was on par with T_4 (0.46 per cent) with Soil-Compost-Paddy husk in the ratio 2:1:1, T_2 (0.38 per cent) with Soil-Compost-Saw dust in the ratio of 2:1:1,

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a titrable acidity of the fruits (0.50 per cent) compared to control (T_1).

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded a titrable acidity of 0.54 per cent and was on par with T_{10} (0.52 per cent) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a lower titrable acidity of the fruits 0.41 per cent compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a lower titrable acidity of the fruits (0.38 per cent) compared to control (T_1).

Among the mulching treatments, T_8 without mulching recorded the titrable acidity of the fruits as 0.56 per cent.

T_9 with standard hybrid Arka Abijith reported 0.49 per cent of titrable acidity of the fruits.

In kharif season, hybrids showed similar trend in titrable acidity of the fruits as in summer except for some treatments. The highest titrable acidity of the fruits has been reported in T_{10} (0.54 per cent) and T_3 (0.54 per cent) and the lowest in T_{11} (0.38 per cent). Among the growing media treatments, the highest titrable acidity of the fruits has been recorded in treatment T_3 (0.54 per cent) par with T_2 (89.32 cm^2 g^{-1}) with Soil-Compost-Saw dust in the ratio 2:1:1 followed by T_4 (88.64 cm^2 g^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison T_5 with irrigation regime of 40 kpa reported a lower specific leaf area (85.53 cm^2 g^{-1}) compared to control.

The treatment T_6 with biofertilizers and K fertilizer as basal has recorded a high specific leaf area (92.05 cm^2 g^{-1}) compared to T_{10} (91.66 cm^2 g^{-1}) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a low specific leaf area of 88.62 cm^2 g^{-1}

The treatment T_{11} with topdressing of NPK fertilizers recorded a specific leaf area of 87.72 cm^2 g^{-1}.

Among the mulching treatments, T_8 without mulching recorded a specific leaf area of (86.82 cm^2 g^{-1}).

T_9 with standard hybrid Arka Abijith reported 91.31 cm^2 g^{-1} as specific leaf area.

In kharif season, hybrids showed similar trend in specific leaf area the as in summer except for some treatments. The highest specific leaf area has been reported in T_6 (94.68 cm^2 g^{-1}) and the lowest in T_{12} (86.74 cm^2 g^{-1}). Among the growing media treatments, the highest specific leaf area has been recorded in treatment T_1 (93.84 cm^2 g^{-1}) followed by T_3 (91.68 cm^2 g^{-1}), which was on par with T_2 (91.32 cm^2 g^{-1}), T_4 (86.62 cm^2 g^{-1}). T_5 has recorded a lower specific leaf area (86.78 cm^2 g^{-1}) compared to control.

Among the treatments with biofertilizer + NPK and K nutrient applications, specific leaf area in T_6 was comparatively higher (94.68 cm^2 g^{-1}) than T_{10} (93.67 cm^2 g^{-1}). T_7 with straight fertilizer fertigation has recorded a low followed by T_1 (0.52 per cent), T_4 (0.48 per cent) and T_2 (0.41 per cent). T_5 has recorded a titrable acidity of the fruits as 0.50 per cent.

Among the treatments with biofertilizer + NPK and K nutrient applications, titrable acidity of the fruits in T_6 was 0.56 per cent and in T_{10}, 0.54 per cent. T_7 has recorded a lower titrable acidity of the fruits as 0.40 per cent compared to control. T_8 has reported a titrable acidity of the fruits as 0.58 per cent. The standard hybrid Arka Abijith recorded 0.50 per cent as titrable acidity of the fruits in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the titrable acidity was maximum in T_6 (0.55 per cent) and minimum in T_{11} (0.38 per cent).

4.3. Physiological characters

4.3.1. Specific leaf area

The data on the specific leaf area of tomato hybrids as influenced by different treatments for two seasons are presented in table 11.

The observations on specific leaf area of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments specific leaf area varied from 85.11 $cm^2\,g^{-1}$ in T_{12} (with spacing 30×22.5 cm) to 92.05 $cm^2\,g^{-1}$ in T_6 (with basal 50 kg ha^{-1} K with straight fertilizer +Azospirillum +PSB).

Among growing media comparisons, T_1 (91.72 $cm^2\,g^{-1}$) with Soil-Compost-Sand in the ratio 2:1:1 obtained the highest specific leaf area, followed by T_3 (89.67 $cm^2\,g^{-1}$) with Soil-Compost-Coco peat in the ratio 2:1:1, which was on

Table 11. Mean performance of hybrids for specific leaf area ($cm^2 g^{-1}$) and leaf area per plant (m^2).

Treatments	Specific leaf area ($cm^2 g^{-1}$)			Leaf area per plant (m^2)		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	91.72	93.84	92.78	1.59	1.61	1.60
T2	89.32	91.32	90.32	1.47	1.48	1.48
T3	89.67	91.68	90.68	1.55	1.56	1.55
T4	88.64	89.62	89.13	1.49	1.51	1.50
T5	85.53	86.78	86.16	1.32	1.34	1.33
T6	92.05	94.68	93.37	1.61	1.65	1.63
T7	88.62	87.68	88.15	1.36	1.39	1.37
T8	86.82	87.14	86.98	1.39	1.42	1.40
T9	91.31	92.34	91.82	1.38	1.45	1.41
T10	91.66	93.67	92.67	1.67	1.69	1.68
T11	87.72	88.44	88.08	1.36	1.37	1.37
T12	85.11	86.74	85.93	1.12	1.13	1.12
Mean	89.01	90.32	89.66	1.44	1.46	1.45
S.Ed	0.2227	0.4682	0.3568	0.4101	0.5363	0.4736
C.D (0.05)	0.4619	0.6893	0.5213	0.8505	0.9233	0.8902
C.D (0.01)	0.6278	0.7564	0.6879	1.1561	1.2784	1.1622

specific leaf area (87.68 cm^2 g^{-1}). T_8 has reported a specific leaf area of 87.14 cm^2. g^{-1}. T_{11} recorded a specific leaf area of 88.44 cm^2 g^{-1}. The standard hybrid Arka Abijith recorded 92.34 cm^2 g^{-1} as specific leaf area in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the specific leaf area was maximum in T_6 (93.37 cm^2 g^{-1}) and minimum in T_{12} (85.93 cm^2 g^{-1}).

4.3.2. Leaf area per plant

The data on the leaf area per plant of tomato hybrids as influenced by different treatments for two seasons are presented in table 11.

The observations on leaf area per plant of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments leaf area per plant varied from 1.12 m^2 in T_{12}, with spacing 30×22.5 cm) to 1.6720 m^2 in T_{10} (with basal 50 kg ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among different growing media comparisons, T_1 (1.59 m^2) with Soil-Compost-Sand in the ratio 2:1:1 obtained the highest leaf area per plant followed by T_3 (1.55 m^2) with Soil-Compost-Coco peat in the ratio 2:1:1, T_4 (1.49 m^2) with Soil-Compost-Paddy husk in the ratio 2:1:1, T_2 (1.47 m^2) with Soil-Compost-Saw dust in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower leaf area per plant (1.32 m^2) compared to control.

The treatment T_{10} with biofertilizers and NPK fertilizers as basal has recorded a high leaf area per plant (1.67 m^2) compared to T_6 (1.61 m^2) with biofertilizers and K fertilizer as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a low leaf area per plant (1.36 m^2) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers recorded a low Leaf area per plant 1.36 m^2 compared to control (T_1).

Among the mulching treatments, T_8 without mulching recorded a low leaf area per plant (1.39 m^2) compared to control (T_1).

T_9 with standard hybrid Arka Abijith reported 1.38 m^2 as leaf area per plant.

In kharif season, hybrids showed similar and enhancing trend in leaf area per plant as in summer except for some treatments. The highest leaf area per plant has been reported in T_{10} (1.67 m^2) and the lowest in T_{12} (1.12 m^2). Among the growing media treatments, the highest leaf area per plant has been recorded in treatment T_1 (1.61 m^2) followed by T_3 (1.56 m^2), T_4 (1.49 m^2) and T_2 (1.48 m^2). T_5 has recorded a leaf area of 1.34 m^2 per plant.

Among the treatments with biofertilizer + NPK and K nutrient applications, leaf area per plant in T_{10} (1.69 m^2) was comparatively higher than T_6 (1.65 m^2). T_7 has recorded a low leaf area per plant (13980 m^2) compared to control. T_8 has reported a low leaf area per plant as 1.42 m^2 compared to control. T_{11} recorded a lower leaf area per plant 1.37 m^2 compared to T_1. The standard hybrid Arka Abijith recorded 1.45 m^2 as leaf area per plant in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the leaf area per plant was maximum in T_{10} (1.68 m^2) and minimum in T_{12} (1.12 m^2).

4.3.3. Leaf area index

The data on the Leaf area index of tomato hybrids as influenced by different treatments for two seasons are presented in table 12.

The observations on leaf area index of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, leaf area index varied from 5.07 in T_{11} (with top dressing of NPK in 5 splits) to T_6 (6.28) with basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T1 (5.97) with Soil-Compost-Sand in the ratio of 2:1:1 obtained the highest leaf area index followed by T_3 (5.76) with Soil-Compost-Coco peat in the ratio of 2:1:1, T_4 (5.54) with Soil-Compost-Paddy husk in the ratio of 2:1:1, T_2 (5.46) with Soil-Compost-Saw dust in the ratio of 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower leaf area index (5.53) compared to control (T_1).

The treatment T_6 with biofertilizers and K fertilizers as basal has recorded a high leaf area index (6.28) compared to T_{10} (6.19) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a low leaf area index (5.25) compared to T_1.

Table 12. Mean performance of hybrids for leaf area index and specific leaf weight (g cm^{-2}).

Treatments	Leaf area index			Specific leaf weight (g cm^{-2})		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	5.97	6.13	6.05	0.010	0.010	0.010
T2	5.46	5.68	5.57	0.011	0.012	0.012
T3	5.76	5.82	5.79	0.011	0.011	0.011
T4	5.54	5.60	5.57	0.013	0.013	0.013
T5	5.53	5.64	5.59	0.014	0.014	0.014
T6	6.28	6.58	6.43	0.010	0.010	0.010
T7	5.25	5.61	5.43	0.012	0.012	0.012
T8	5.14	5.44	5.29	0.013	0.014	0.013
T9	5.12	5.52	5.32	0.011	0.010	0.010
T10	6.19	6.42	6.31	0.010	0.010	0.010
T11	5.07	5.12	5.09	0.012	0.012	0.012
T12	5.20	5.20	5.20	0.013	0.014	0.013
Mean	5.67	5.81	5.74	0.0116	0.0118	0.0117
S.Ed	0.0581	0.0672	0.0567	0.0001	0.0001	0.0001
C.D (0.05)	0.1204	0.1345	0.1282	0.0002	0.0002	0.0002
C.D (0.01)	0.1637	0.1721	0.1642	0.0003	0.0003	0.0003

The treatment T_{12} (with reduced spacing) recorded a low leaf area index (5.07) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a low leaf area index (5.14) compared to T_1.

T_9 with standard hybrid Arka Abijith reported 5.12 as leaf area index.

In kharif season, hybrids showed similar trend in leaf area index as in summer. The highest leaf area index has been reported in T_6 (6.58) and the lowest in T_{11} (5.12). Among the growing media treatments, the highest leaf area index has been recorded in T_1 (6.13) followed by T_3 (5.82), T_2 (5.68) and T_4 (5.60). T_5 has recorded a leaf area index of 5.64.

Among the treatments with biofertilizer + NPK and K nutrient applications, Leaf area index of T_6 (6.58) was comparatively higher than T_{10} (6.42). T_7 has recorded a lower leaf area index (5.61) compared to control. T_8 has also reported a lower leaf area index of 5.44 compared to control. T_{12} recorded a leaf area index of 5.2 and the standard hybrid Arka Abijith recorded 5.52 as leaf area index in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the leaf area index was maximum in T_6 (6.43) and minimum in T_{12} (5.20).

4.3.4. Specific leaf weight

The data on the specific leaf weight of tomato hybrids as influenced by different treatments for two seasons are presented in table 12.

The observations on specific leaf weight of the hybrids showed not much difference among the different treatments during both the experimental seasons.

Among growing media comparisons, T_4 (0.012 gcm^{-2}) with growing media of Soil-Compost-Paddy husk in the ratio 2:1:1, obtained the highest specific leaf weight followed by, T_2 (0.011 g cm^{-2}) with Soil-Compost-Saw dust in the ratio 2:1:1, which was on par with T_3 (0.011 g cm^{-2}) with Soil-Compost-Coco peat in the ratio 2:1:1 and T_1 (0.010 g cm^{-2}) with Soil- Compost-Sand in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported the highest specific leaf weight (0.014 g cm^{-2}) compared to all other treatments.

The treatment T_{10} (with biofertilizers and NPK fertilizers as basal) and T_6 (with biofertilizers and K fertilizers as basal) have recorded a specific leaf weight of 0.010 g cm^{-2} and were on par with control.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a high specific leaf weight (0.012 g cm^{-2}) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers recorded a high specific leaf weight (0.012 g cm^{-2}) compared to control.

Among the mulching treatments, T_8 without mulching recorded a high specific leaf weight (0.013 g cm^{-2}) compared to control.

T_9 with standard hybrid Arka Abijith recorded a low specific leaf weight of 0.011 g cm^{-2}.

In kharif season, hybrids showed similar trend in specific leaf weight as in summer. The highest specific leaf weight has been reported in treatments T_5,

T_8 and T_{12} (0.014 g cm^{-2}) and the lowest in treatments T_1, T_6, T_9 and T_{10}. (0.010 g cm^{-2}).

Among the growing media treatments, the highest specific leaf weight has been recorded in T_4 (0.013 g cm^{-2}) followed by T_2 (0.012 g cm^{-2}), T_3 (0.011 g cm^{-2}) and T_1 (0.010 g cm^{-2}). The treatment with irrigation regime 40 kpa, T_5 has recorded a specific leaf weight of 0.016 g cm^{-2}. T_7 recorded a specific leaf weight of 0.012 g cm^{-2} and T_{11} recorded 0.012 g cm^{-2} as specific leaf weight in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the specific leaf weight was maximum in T_5 (0.014 g cm^{-2}) and minimum in T_1, T_6, T_9 and T_{10} (0.010 g cm^{-2}).

4.3.5. Crop growth rate

The data on the crop growth rate of tomato hybrids as influenced by different treatments for two seasons are presented in table 13.

The observations on crop growth rate of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, crop growth rate varied from 17.02 g m^{-2} day^{-1} in T_{12} (with spacing 30×22.5 cm) to T_{10} (18.80 g m^{-2} day^{-1}) (with basal 50 kg ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, T_4 (18.63 g m^{-2} day^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1, obtained the highest crop growth rate followed by T_1 (18.54 g m^{-2} day^{-1}) with of Soil-Compost-Sand in the ratio of 2:1:1, T_2 (18.31 g m^{-2} day^{-1}) with Soil-Compost-Saw dust in the ratio 2:1:1, and was on par with T_3 (18.21 g m^{-2} day^{-1}) with Soil-Compost-Coco peat in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a lower crop growth rate (17.92 g m^{-2} day^{-1}) compared to T_1 with irrigation regime of 20 kpa.

The treatment T_{10} with biofertilizers and NPK fertilizers as basal has recorded a high crop growth rate (18.80 g m^{-2} day^{-1}) than T_6 (18.76 g m^{-2} day^{-1}) with biofertilizers and K fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded lower crop growth rate (18.22 g m^{-2} day^{-1}) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a low crop growth rate (19.21 g m^{-2} day^{-1}) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a low crop growth rate (17.78 g m^{-2} day^{-1}) compared to control.

T_9 with standard hybrid Arka Abijith recorded 17.69 g m^{-2} day^{-1} as crop growth rate.

In kharif season, hybrids showed similar trend in crop growth rate except for some treatments as in summer. The highest crop growth rate has been reported in T_{10} (19.98 g m^{-2} day^{-1}) and the lowest in T_{12} (17.28 g m^{-2} day^{-1}). Among the growing media treatments, the highest crop growth rate has been recorded in treatment T_1 (19.64 g m^{-2} day^{-1}) followed by T_3 (19.58 g m^{-2} day^{-1}), T_2 (19.12 g m^{-2} day^{-1}) and T_4 (19.01 g m^{-2} day^{-1}). T_5 has recorded a low Crop growth rate (18.62 g m^{-2} day^{-1}) compared to control.

Among the treatments with biofertilizer + NPK and K nutrient applications, crop growth rate of T_{10} (19.98 g m^{-2} day^{-1}) was comparatively

Table 13. Mean performance of hybrids for crop growth rate (g m^{-2} day^{-1}) and net assimilation rate (g m^{-2} day^{-1}).

Treatments	Crop growth rate (g m^{-2} day^{-1})			Net assimilation rate (g m^{-2} day^{-1})		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	18.54	19.64	19.09	10.85	11.64	11.25
T2	18.31	19.12	18.75	11.50	12.55	12.03
T3	18.21	19.58	18.89	11.12	12.15	11.64
T4	18.63	19.01	18.82	11.46	12.50	11.98
T5	17.92	17.98	17.95	11.49	12.86	12.18
T6	18.76	19.92	19.34	10.12	11.14	10.63
T7	18.22	18.22	18.22	11.82	12.63	12.23
T8	17.78	18.14	17.96	11.95	12.53	12.24
T9	17.69	18.60	18.15	11.98	12.45	12.22
T10	18.80	19.98	19.39	10.06	11.05	10.55
T11	18.12	18.22	18.17	12.02	12.98	12.50
T12	17.02	17.28	17.24	12.35	13.05	12.70
Mean	18.16	18.72	18.44	11.39	12.28	11.83
S.Ed	0.1683	0.1734	0.0169	0.0789	0.0932	0.0868
C.D (0.05)	0.3490	0.4432	0.3979	0.1636	0.1834	0.1729
C.D (0.01)	0.4744	0.5623	0.5236	0.2224	0.3867	0.2892

higher than T_6 (19.92 g m^{-2} day^{-1}). T_7 has recorded a low crop growth rate (18.22 g m^{-2} day^{-1}) compared to T_1. T_8 has reported a lower crop growth rate 18.73 g m^{-2} day^{-1} than control. Top-dressing treatment, T_{11} also recorded a low crop growth rate (18.42 g m^{-2} day^{-1}) compared to control. The standard hybrid Arka Abijith recorded crop growth rate as 18.60 g m^{-2} day^{-1} in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the crop growth rate was maximum in T_{10} (19.39 g m^{-2} day^{-1}) and minimum in T_{12} (17.24 g m^{-2} day^{-1}).

4.3.6. Net assimilation rate

The data on the net assimilation rate of tomato hybrids as influenced by different treatments for two seasons are presented in table 13.

The observations on net assimilation rate of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, net assimilation rate varied from 12.35 g m^{-2} day^{-1} in T_{12} (with spacing 30×22.5 cm) to 10.06 in T_{10} (with basal 50 kg ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among growing media comparisons, treatment, T_2 (11.50 g m^{-2} day^{-1}) with Soil-Compost-Saw dust in the ratio 2:1:1, obtained the highest net assimilation rate followed by T_4 (11.46 g m^{-2} day^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1, T_3 (11.12 g m^{-2} day^{-1}) with Soil-Compost-Coco peat in the ratio 2:1:1 and T_1 (10.85 g m^{-2} day^{-1}) with of Soil-Compost-Sand in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported a high net assimilation rate (10.72 g m^{-2} day^{-1}) compared to control (T_1).

The treatment T_6 (10.12 g m^{-2} day^{-1}) with biofertilizers and K fertilizers as basal and T_{10} (10.06 g m^{-2} day^{-1}) with biofertilizers and NPK fertilizers as basal has recorded the lowest net assimilation rate compared to all other treatments.

The treatment T_7 consisting of fertigation with straight fertilizers recorded low net assimilation rate (11.12 g m^{-2} day^{-1}) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers recorded lower (10.98 g m^{-2} day^{-1}) net assimilation rate compared to control.

Among the mulching treatments, T_8 without mulching recorded a net assimilation rate of 11.95 g m^{-2} day^{-1}.

T_9 with standard hybrid Arka Abijith recorded 11.98 g m^{-2} day^{-1} as net assimilation rate.

In kharif season, hybrids showed similar trend in net assimilation rate as in summer. The highest net assimilation rate has been reported in T_{12} (13.05 g m^{-2} day^{-1}) and the lowest in T_{10} (11.14 g m^{-2} day^{-1}). Among the growing media treatments, the highest net assimilation rate has been recorded in treatment T_2 (12.55 g m^{-2} day^{-1}) followed by T_4 (12.50 g m^{-2} day^{-1}), T_3 (12.15 g m^{-2} day^{-1}) and T_1 (11.64 g m^{-2} day^{-1}). T_5 has recorded a high net assimilation rate (12.86 g m^{-2} day^{-1}) compared to control.

Among the treatments with biofertilizer + NPK and K nutrient applications, net assimilation rate of T_6 (11.14 g m^{-2} day^{-1}) and T_{10} (11.05 g m^{-2} day^{-1}) were reported to be low among all the treatments. T_7 has recorded a high net assimilation rate (12.63 g m^{-2} day^{-1}) compared to control. T_8 recorded a net assimilation rate of 12.53 g m^{-2} day^{-1}. T_{11} recorded a high net assimilation rate (12.98 g m^{-2} day^{-1}) compared to T_1. The standard hybrid Arka Abijith recorded crop growth rate as 12.45 g m^{-2} day^{-1} in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the net assimilation rate was maximum in T_{12} (12.70 g m^{-2} day^{-1}) and minimum in T_{10} (10.55 g m^{-2} day^{-1}).

4.3.7. Relative water content

The data on the relative water content tomato hybrids as influenced by different treatments for two seasons are presented in table 14.

The observations on relative water content of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, relative water content varied from 84.32 per cent in T_5 (with Irrigation regime of 40 Kpa) to 90.42 per cent in T_3 (with growing media of Soil- Compost- Coco peat in the ratio of 2:1:1).

Among growing media comparison, T_3 (90.42 per cent) with Soil-Compost-Coco peat in the ratio 2:1:1, obtained the highest relative water content followed by T_2 (89.41 per cent) with Soil-Compost-Saw dust in the ratio 2:1:1, T_4 (89.21 per cent) with Soil-Compost-Paddy husk in the ratio of 2:1:1, T_1 (88.21 per cent) with of Soil-Compost-Sand in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported the lowest relative water content (84.32 per cent) compared to control.

Table 14. Mean performance of hybrids for relative water content (per cent) in the plant.

Treatments	Relative water content (per cent)		
	Summer	Kharif	Mean
T1	88.21	90.24	89.23
T2	89.41	92.82	91.03
T3	90.42	94.60	92.51
T4	89.21	92.16	90.69
T5	84.32	85.25	84.79
T6	89.01	92.64	90.87
T7	86.48	88.52	87.5
T8	86.42	87.35	86.89
T9	88.18	90.50	89.34
T10	89.64	92.84	91.24
T11	86.31	87.08	86.69
T12	85.49	86.12	85.80
Mean	87.75	90.01	88.88
S.Ed	0.0248	0.0432	0.0346
C.D (0.05)	0.0514	0.0674	0.0592
C.D (0.01)	0.0699	0.0834	0.0778

The treatment T_{10} with biofertilizers and NPK fertilizers as basal has recorded higher relative water content (89.64 per cent) than T_6 (89.01 per cent) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded lower relative water content (86.48 per cent) compared to control.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a low crop growth rate (86.31 per cent) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded a relative water content 86.42 per cent compared to T_1.

T_9 with standard hybrid Arka Abijith recorded 88.18 per cent as relative water content.

In kharif season, hybrids showed similar trend in relative water content rate as in summer. The highest relative water content has been reported in T_3 (94.60 per cent) and the lowest in T_5 (85.95 per cent). Among the growing media treatments, the highest relative water content has been recorded in treatment T_3 (94.64 per cent) followed by T_2 (92.82 per cent), T_4 (92.16 per cent) and T_1 (90.24 per cent).

Among the treatments with biofertilizer + NPK and K nutrient applications, relative water content of T_{10} (92.84 per cent) was on par with T_6 (92.64 per cent). T_7 has recorded a lower relative water content (88.52 per cent) compared to control. T_8 without mulching has reported lower relative water content (87.35 per cent) compared to T_1. T_{11} also recorded a low relative water content (87.08 per cent) compared to T_1. The standard hybrid Arka Abijith recorded a relative water content of 90.50 per cent in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the relative water content was maximum in T_3 (92.51 per cent) and minimum in T_5 (84.79 per cent).

4.4. Nutrient analysis in media

The results of the nutrient analysis in media carried out in four different growing media for three major nutrients at the time of harvest are discussed in the order of growing media, irrigation regime, straight fertilizer, mulching, top dressing of fertilizer and spacing comparisons.

4.4.1. Available nitrogen content

The data on the available nitrogen content of the media as influenced by different treatments for two seasons are presented in table 15.

The observations on available nitrogen content of the media showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, available nitrogen content varied from 185.76 kg ha^{-1} in T_{12} (with of spacing 30×22.5 cm) to 190.62 kg ha^{-1} in T_{10} (with basal 50 kg ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among different growing media comparison, T_3 (190.03 kg ha^{-1}) with Soil-Compost-Coco peat in the ratio 2:1:1, obtained the highest available nitrogen content followed by T_2 (189.42 kg ha^{-1}) with Soil-Compost-Saw dust in the ratio 2:1:1, T_4 (189.13 kg ha^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1 and T_1 (187.58 kg ha^{-1}) with Soil-Compost-Sand in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported low available nitrogen content (186.80 kg ha^{-1}) compared to control (T_1).

The treatment T_{10} (190.62 kg ha^{-1}) with biofertilizers and NPK fertilizers as basal has recorded high available nitrogen content than control and was on par with T_6 (190.30 kg ha^{-1}) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded lower available nitrogen content (187.00 kg ha^{-1}) than T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a low available nitrogen content (186.20 kg ha^{-1}) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded available nitrogen content of 186.70 kg ha^{-1}.

T_9 with standard hybrid Arka Abijith recorded 187.10 kg ha^{-1} as available nitrogen content.

In kharif season, media showed similar trend in nitrogen content as in summer. The highest available nitrogen content has been reported in T_{10} (192.44 kg ha^{-1}) and the lowest in T_{12} (185.82 kg ha^{-1}). Among the growing media treatments, the highest available nitrogen content has been recorded in treatment T_3 (191.72 kg ha^{-1}) followed by T_2 (191.68 kg ha^{-1}), T_4 (191.14 kg ha^{-1}) and T_1 (190.38 kg ha^{-1}). T_5 has recorded a low available nitrogen content (187.92 kg ha^{-1}) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, available nitrogen content of T_{10} (192.44 kg ha^{-1}) was on par with T_6 (192.28 kg ha^{-1}). T_7 has recorded a low available nitrogen content (190.00 kg ha^{-1}) compared to T_1. T_8 has also reported low available nitrogen content

Table 15. Mean performance of hybrids for available nitrogen (Kg ha^{-1}) and phosphorus content (kg ha^{-1}) of the media.

Treatments	Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	187.58	190.38	188.78	25.81	26.90	26.30
T2	189.42	191.68	190.55	23.31	23.14	22.53
T3	190.03	191.72	190.88	25.81	26.90	26.30
T4	189.13	191.14	190.14	24.40	24.44	22.93
T5	186.80	187.92	187.36	23.80	24.18	24.00
T6	190.30	192.28	191.24	26.41	27.53	26.73
T7	187.00	190.00	188.15	23.40	23.45	23.42
T8	186.70	188.18	187.74	23.80	24.12	23.96
T9	187.10	190.04	188.42	24.92	25.62	25.27
T10	190.62	192.44	191.58	26.14	27.18	26.61
T11	186.20	187.25	186.72	22.50	22.42	22.46
T12	185.76	185.82	185.79	22.10	22.13	22.17
Mean	188.01	189.91	188.92	24.27	24.89	24.88
S.Ed	0.2518	0.3245	0.2862	0.1985	0.1998	0.1992
C.D (0.05)	0.5223	0.7843	0.6472	0.4116	0.4231	0.4189
C.D (0.01)	0.7099	0.8765	0.8212	0.5595	0.5612	0.5602

(188.18 kg ha^{-1}) compared to control. T_{11} has reported to contain a low available nitrogen content (187.25 kg ha^{-1}) compared to control. The standard hybrid Arka Abijith recorded available nitrogen content as 190.04 kg ha^{-1} in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the available nitrogen was maximum in T_{10} (191.58 kg ha^{-1}) and minimum in T_{12} (185.79 kg ha^{-1}).

4.4.2. Available phosphorus content

The data on the available phosphorus content of the media as influenced by different treatments for two seasons are presented in table 15.

The observations on available phosphorus content of the media showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, available phosphorus content varied from 22.10 kg ha^{-1} in T_{12} (with of spacing 30×22.5 cm) to 26.41 kg ha^{-1} in T_6 (basal 50 kg ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among different growing media comparison, treatment, T_1 (25.81 kg ha^{-1})with of Soil-Compost-Sand in the ratio 2:1:1, obtained the highest available phosphorus content which was on par with T_3 (25.81 kg ha^{-1}) with Soil-Compost-Coco peat in the ratio 2:1:1 followed by T_4 (24.40 kg ha^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1 and T_2 (23.31 kg ha^{-1}) with Soil-Compost-Saw dust in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported an available phosphorus content of 23.80 kg ha^{-1}.

The treatment T_6 with biofertilizers and K fertilizers as basal has recorded highest available phosphorus content (26.41 kg ha^{-1}) and was on par with T_{10} (26.14 kg ha^{-1}) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded low available phosphorus content (23.40 kg ha^{-1}) compared to T_1.

The treatment T_{11} with topdressing of NPK fertilizers also recorded a low available phosphorus content (22.50 kg ha^{-1}) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded soil phosphorus content of 23.80 kg ha^{-1}. T_9 with standard hybrid Arka Abijith recorded an available phosphorus content of 24.92 kg ha^{-1}.

In kharif season, media showed similar and enhancing trend in available phosphorus content compared to summer. The highest available phosphorus content has been reported in T_6 (27.23 kg ha^{-1}) and the lowest in T_{12} (22.13 kg ha^{-1}). Among the growing media treatments, the highest available phosphorus content has been recorded in treatment T_1 (26.90 kg ha^{-1}), which was on par with T_3 (26.90 kg ha^{-1}), followed by T_4 (24.44 kg ha^{-1}) and T_2 (23.14 kg ha^{-1}). T_5 has recorded a lower available phosphorus content (24.18 kg ha^{-1}) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, available phosphorus content of T_6 (27.53 kg ha^{-1}) was on par with T_{10} (27.18 kg ha^{-1}). T_7 has recorded available phosphorus content of 23.45 kg ha^{-1} T_8 has reported soil phosphorus content of 24.12 kg ha^{-1}. Available phosphorus content of T_{11} was 22.42 kg ha^{-1}. The standard hybrid Arka Abijith recorded an available phosphorus content of 25.62 kg ha^{-1} in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the available phosphorus was maximum in T_6 (26.73 kg ha^{-1}) and minimum in T_{12} (22.17 kg ha^{-1}) taken both seasons together.

4.4.3. Available potassium content

The data on the available potassium content of the media as influenced by different treatments for two seasons are presented in table 16.

The observations on available potassium content of the media showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, available potassium content varied from 646.41 kg ha^{-1} in T_4 (with growing media of Soil- Compost-Paddy husk in the ratio 2:1:1) to 663.61 kg ha^{-1} in T_{10} (with basal 50 kg ha^{-1} NPK with straight fertilizer.+ Azospirillum + PSB).

Among different growing media comparison, treatment, T_1 (662.57 kg ha^{-1}) with of Soil-Compost-Sand in the ratio 2:1:1, obtained the highest available potassium content followed by T_2 (656.15 kg ha^{-1}), with Soil-Compost-Saw dust in the ratio 2:1:1, T_3 (650.54 kg ha^{-1}) with Soil-Compost-Coco peat in the ratio 2:1:1, T_4 (646.41 kg ha^{-1}) with Soil-Compost-Paddy husk in the ratio 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported available potassium content of 661.11 kg ha^{-1}.

The treatment T_6 with biofertilizers and K fertilizers as basal has recorded the highest available potassium content (663.10 kg ha^{-1}) and was on par with T_{10} (663.61 kg ha^{-1}) with biofertilizers and NPK fertilizers as basal.

Table 16. Mean performance of hybrids for available potassium content (Kg ha^{-1}) of the media.

Treatments	Available potassium (Kg ha^{-1})		
	Summer	Kharif	Mean
T1	662.57	664.26	663.33
T2	656.15	658.38	657.25
T3	650.54	652.56	651.55
T4	646.41	647.42	646.92
T5	661.11	662.12	661.82
T6	663.10	665.56	664.33
T7	662.21	663.38	662.99
T8	661.40	662.48	661.94
T9	662.98	664.02	663.58
T10	663.61	665.82	664.68
T11	661.15	661.68	661.55
T12	660.80	661.32	661.07
Mean	659.51	659.49	659.50
S.Ed	0.1707	0.1723	0.1718
C.D (0.05)	0.3540	0.3612	0.3426
C.D (0.01)	0.4812	0.4893	0.4867

The treatment T_7 consisting of fertigation with straight fertilizers recorded available potassium content of 662.21 kg ha^{-1}.

Available potassium content of T_{11} with topdressing of NPK fertilizers was 661.15 kg ha^{-1}.

Among the mulching treatments, T_8 without mulching recorded available potassium content of 661.40 kg ha^{-1}.

T_9 with standard hybrid Arka Abijith recorded available potassium content of 662.98 kg ha^{-1}.

In kharif season, media showed similar trend in available potassium content, as in summer. The highest available potassium content has been reported in T_{10} (665.82 kg ha^{-1}) and the lowest in T_{12} (661.32 kg ha^{-1}). Among the growing media treatments, the highest available potassium content has been recorded in T_1 (664.26 kg ha^{-1}) followed by T_2 (658.38 kg ha^{-1}), T_3 (652.56 kg ha^{-1}) and T_4 (647.42 kg ha^{-1}). T_5 has recorded soil potassium content of 662.12 kg ha^{-1}.

Among the treatments with biofertilizer + NPK and K nutrient applications, T_{10} reported a higher available potassium content of (665.82 kg ha^{-1}), which was on par with T_6 (665.56 kg ha^{-1}). T_7 has recorded a soil potassium content 663.38 kg ha^{-1}. T_8 has reported soil potassium content of 662.48 kg ha^{-1}. Soil potassium content of T_{11} was 662.68 kg ha^{-1}. The standard hybrid Arka Abijith recorded available potassium content of 664.32 kg ha^{-1} in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the available potassium was maximum in T_{10} (664.68 kg ha^{-1}) and minimum in T_{12} (661.07 kg ha^{-1}) taken both seasons together.

4.5 Plant nutrient analysis

The results of the plant nutrient analysis carried out for three major nutrients at the time of harvest are discussed in the order of growing media, irrigation regime, straight fertilizer, mulching, top dressing of fertilizer and spacing comparisons.

4.5.1 Plant nitrogen content

The data on the plant nitrogen content of tomato hybrids as influenced by different treatments for two seasons are presented in table 17.

The observations on plant nitrogen content of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, plant nitrogen content varied from 2.66 percentage in T_{12} (with of spacing 30×22.5 cm) to 3.82 per cent in T_{10} (with basal 50 Kg Ha^{-1} NPK with straight fertilizer + Azospirillum + PSB).

Among different growing media comparison, T_1 (3.62 per cent) with of Soil-Compost-Sand in the ratio 2:1:1, obtained the highest plant nitrogen content followed by T_3 (3.58 per cent) with Soil-Compost-Coco peat in the ratio of 2:1:1, that was on par with T_2 (3.56 per cent), with Soil-Compost-Saw dust in the ratio of 2:1:1 and T_4 (3.48 per cent) with Soil-Compost-Paddy husk in the ratio of 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported plant nitrogen content of 23.80 per cent.

The treatment T_{10} (3.82 per cent) with biofertilizers and NPK fertilizers as basal has recorded the highest plant nitrogen content and was higher than T_6 (3.76 per cent) with biofertilizers and K fertilizers as basal.

The treatment T_7, consisting of fertigation with straight fertilizers recorded lower plant nitrogen content of 2.92 per cent.

The treatment T_{11} with topdressing of NPK fertilizers also recorded low plant nitrogen content (2.76 per cent) compared to control.

Among the mulching treatments, T_8 without mulching recorded low plant nitrogen content (3.15 per cent) compared to control.

T_9 with standard hybrid Arka Abijith recorded plant nitrogen content of 3.20 per cent.

In kharif season, hybrids showed similar and enhancing trend in plant nitrogen content as in summer. The highest plant nitrogen content has been reported in T_{10} (4.10 per cent) and the lowest in T_{12} (2.82 per cent). Among the growing media treatments, the highest plant nitrogen content has been recorded in treatment T_1 (3.92 per cent) followed by T_2 (3.84 per cent), followed by T_3 (3.62 per cent), T_4 (3.52 per cent). T_5 has recorded low plant nitrogen content (3.21 per cent) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, T_{10} reported a plant nitrogen content of (4.10 per cent), which was on par with T_6 (4.02 per cent). T_7 has recorded low plant nitrogen content (3.14 per cent) compared to T_1. T_8 has reported low plant nitrogen content (3.23 per cent) compared to T_1. Plant nitrogen content of T_{11} (2.98 per cent) was comparatively lower than T_1. The standard hybrid Arka Abijith recorded plant nitrogen content of 3.35 per cent in kharif.

Table 17. Mean performance of hybrids for plant nitrogen (per cent) and phosphorus (per cent) content.

Treatments	Plant nitrogen content (per cent)			Plant phosphorus content (per cent)		
	Summer	Kharif	Mean	Summer	Kharif	Mean
T1	3.62	3.92	3.77	0.68	0.72	0.70
T2	3.56	3.84	3.70	0.52	0.56	0.54
T3	3.58	3.62	3.60	0.62	0.66	0.64
T4	3.48	3.52	3.50	0.48	0.52	0.50
T5	3.18	3.21	3.19	0.42	0.46	0.44
T6	3.76	4.02	3.89	0.72	0.80	0.76
T7	2.92	3.14	3.03	0.38	0.42	0.40
T8	3.15	3.23	3.19	0.44	0.46	0.45
T9	3.20	3.35	3.28	0.56	0.60	0.58
T10	3.82	4.10	3.96	0.78	0.82	0.80
T11	2.76	2.98	2.87	0.32	0.46	0.39
T12	2.66	2.82	2.74	0.33	0.38	0.35
Mean	3.31	3.48	3.39	0.57	0.57	0.57
S.Ed	0.0235	0.0323	0.0269	0.0184	0.0196	0.0189
C.D (0.05)	0.0487	0.0654	0.0563	0.0381	0.0423	0.0388
C.D (0.01)	0.4812	0.6212	0.5273	0.0518	0.0745	0.0614

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the plant nitrogen content was maximum in T_{10} (3.96 per cent) and minimum in T_{12} (2.74 per cent).

4.5.2 Plant phosphorus content

The data on the plant phosphorus content of tomato hybrids as influenced by different treatments for two seasons are presented in table 17.

The observations on plant phosphorus content of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, plant phosphorus content varied from 0.32 per cent in T_{11} (with Top dressing of NPK in 5 splits) to 0.78 per cent in T_{10} (basal 50 Kg Ha^{-1} NPK with straight fertilizer + Azospirillum + PSB)

Among different growing media comparison, treatment, T_1 (0.66 per cent) with of Soil-Compost-Sand in the ratio 2:1:1, obtained the highest plant phosphorus content followed by T_3 (0.62 per cent) with Soil-Compost-Coco peat in the ratio 2:1:1, T_2 (0.52 per cent), with Soil-Compost-Saw dust in the ratio 2:1:1 and T_4 (0.48 per cent) with Soil-Compost-Paddy husk in the ratio of 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported low plant phosphorus content (0.42 per cent) compared to control (T_1).

The treatment T_{10} with biofertilizers and NPK fertilizers as basal has recorded the highest plant phosphorus content (0.78 per cent) and was higher than T_6 (0.72 per cent) with biofertilizers and K fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a lower plant phosphorus content (0.38 per cent) compared to control (T_1).

Among the mulching treatments, T_8 without mulching recorded lower plant phosphorus content (0.44 per cent) compared to T_1.

T_9 with standard hybrid Arka Abijith recorded plant phosphorus content of 0.56 per cent.

In kharif season, hybrids showed similar trend in plant phosphorus content, as in summer. The highest plant phosphorus content has been reported in T_{10} (0.82 per cent) and the lowest in T_{12} (0.38 per cent). Among the growing media treatments, the highest plant nitrogen content has been recorded in treatment T_1 (0.72 per cent) followed by T_3 (0.66 per cent), T_2 (0.56 per cent) and T_4 (0.52 per cent). T_5 has recorded low plant phosphorus content (0.42 per cent) compared to T_1.

Among the treatments with biofertilizer + NPK and K nutrient applications, T_{10} reported the highest plant phosphorus content (0.82 per cent) and was on par with T_6 (0.86 per cent). T_7 with straight fertilizer fertigation has recorded low plant phosphorus content (0.42 per cent) compared to T_1. T_8 has reported low plant phosphorus content (0.46 per cent) compared to T_1. Plant phosphorus content of T_{11} was (0.46 per cent) was lower than T_1. The standard hybrid Arka Abijith recorded plant phosphorus content of 0.60 per cent in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the plant nitrogen was maximum in T_{10} (0.80 per cent) and minimum in T_{12} (0.35 per cent).

4.5.3. Plant potassium content

The data on the plant potassium content of tomato hybrids as influenced by different treatments for two seasons are presented in table 18.

The observations on plant potassium content of the hybrids showed a significant difference among the different treatments during both the experimental seasons.

In summer, among the different treatments, plant potassium content varied from 3.70 per cent in T_{11} (with top dressing of NPK in 5 splits) to 4.85 per cent in T_6 (with basal 50 Kg Ha^{-1} K with straight fertilizer + Azospirillum + PSB).

Among different growing media comparison, T_1 (4.62 per cent) with of Soil-Compost-Sand in the ratio 2:1:1, obtained the highest plant potassium content followed by T_3 (4.38 per cent) with Soil-Compost-Coco peat in the ratio 2:1:1, T_4 (4.30 per cent) with Soil-Compost-Paddy husk in the ratio 2:1:1, which was on par with T_2 (4.29 per cent), with Soil-Compost-Saw dust in the ratio of 2:1:1.

Among the irrigation regime comparison, T_5 with irrigation regime of 40 kpa reported low plant potassium content (3.92 per cent) compared to control (T_1).

The treatment T_6 (4.85 per cent) with biofertilizers and K fertilizers as basal has recorded the highest plant potassium content and was on par with T_{10} (4.80 per cent) with biofertilizers and NPK fertilizers as basal.

The treatment T_7 consisting of fertigation with straight fertilizers recorded a low plant potassium content (3.78 per cent) compared to T_1.

Among the mulching treatments, T_8 without mulching recorded low plant potassium content (4.05 per cent) compared to T_1.

Table 18. Mean performance of hybrids for plant potassium content (per cent).

Treatments	Plant potassium content (per cent)		
	Summer	Kharif	Mean
T1	4.62	4.82	4.72
T2	4.28	4.44	4.36
T3	4.38	4.42	4.40
T4	4.30	4.34	4.32
T5	3.92	4.08	4.00
T6	4.85	4.92	4.86
T7	3.78	3.86	3.82
T8	4.05	4.14	4.09
T9	4.44	4.62	4.53
T10	4.80	4.88	4.84
T11	3.70	3.92	3.81
T12	3.72	3.81	3.77
Mean	4.24	4.35	4.29
S.Ed	0.0285	0.0321	0.0289
C.D (0.05)	0.0591	0.0698	0.0602
C.D (0.01)	0.0803	0.0986	0.0859

T_9 with standard hybrid Arka Abijith recorded plant potassium content of 4.40 per cent.

In kharif season, hybrids showed similar and enhancing trend in plant potassium content, compared to summer. The highest plant potassium content has been reported in T_6 (4.92 per cent) and the lowest in T_{11} (3.92 per cent). Among the growing media treatments, the highest plant potassium content has been recorded in treatment T_1 (4.82 per cent) followed by T_2 (4.44 per cent), which was on par with T_3 (4.42 per cent) and T_4 (4.34 per cent). T_5 has recorded low plant potassium content (4.08 per cent) compared to control (T_1).

Among the treatments with biofertilizer +NPK and K nutrient applications, T_6 reported the highest plant potassium content (4.92 per cent) and was higher than T_{10} (4.88 per cent). T_7 has recorded low plant potassium content (3.86 per cent) compared to T_1. T_8 has reported low plant potassium content (4.14 per cent) compared to T_1. . The standard hybrid Arka Abijith recorded plant potassium content of 4.52 per cent in kharif.

Among all the treatments, the mean performance of the hybrids for both the seasons revealed that the plant potassium content was maximum in T_6 (4.86 per cent) and minimum in T_{12} (3.77 per cent).

4.6. Correlation studies

The results of simple correlation of quantitative and quality characters with yield (Table 19), physiological characters with yield (Table 20) and available media and plant nutrient content with yield (Table 21) are discussed below.

TABLE 19. SIMPLE CORRELATION OF QUANTITATIVE AND QUALITY CHARACTERS

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X1	--	0.452**	0.022	0.077	-0.094	-0.091	0.061	-0.069	-0.126	0.312*	0.158	-0.025	-0.280	-0.071	-0.051	-0.487**
X2		--	0.516**	0.560**	0.647**	0.700**	0.573**	0.569**	0.667**	0.407*	-0.880**	-0.672**	0.730**	0.338*	0.501**	0.731**
X3			--	0.944**	0.563**	0.845**	0.885**	0.762**	0.855**	0.540**	-0.613**	-0.368*	0.682**	0.526**	0.877**	0.741**
X4				--	0.709**	0.860**	0.949**	0.868**	0.893**	0.686**	-0.594**	-0.392*	0.700**	0.621**	0.929**	0.763**
X5					--	0.656**	0.839**	0.860**	0.738**	0.569**	-0.569**	-0.371*	0.869**	0.614**	0.763**	0.737**
X6						--	0.799**	0.736**	0.813**	0.550**	-0.702**	-0.563**	0.757**	0.445**	0.879**	0.791**
X7							--	0.868**	0.894**	0.723**	-0.625**	-0.424*	0.764**	0.650**	0.917**	0.748**
X8								--	0.768**	0.490**	-0.474**	-0.134	0.845**	0.751**	0.863**	0.849**
X9									--	0.749**	-0.725**	-0.566**	0.783**	0.595**	0.812**	0.816**
X10										--	-0.546**	-0.643**	0.374*	0.468**	0.529**	0.341**
X11											--	0.839**	0.698**	-0.111	-0.462	-0.616**
X12												--	-0.379*	0.092	-0.283	-0.264**
X13													--	0.449**	0.742**	0.892**
X14														--	0.646**	0.561**
X15															--	0.795**
X16																--

** - P.01 * - P.05

X1	PLANT HEIGHT		
X2	DAYS TO 50 PER CENT FLOWERING	X13	TOTAL SUGARS
X3	FLOWER CLUSTERS PER PLANT	X14	TOTAL ACIDTY
X4	FLOWERS PER CLUSTER	X15	ASCORBIC ACID
X5	FRUIT SETTING PERCENTAGE	X16	YIELD PER PLANT
X6	FRUIT CLUSTERS PER PLANT		
X7	FRUITS PER CLUSTER		
X8	SINGLE FRUIT WEIGHT		
X9	POLAR DIAMETER		
X10	EQUATORIAL DIAMETER		
X11	FRUIT FIRMNESS		
X12	TOTAL SOLUBLE SOLIDS		

TABLE 20. SIMPLE CORRELATION OF PHYSIOLOGICAL CHARCTERS WITH YIELD

	X1	X2	X3	X4	X5	X6	X7	X8
X1	--	0.864**	0.512**	-0.948**	0.857**	-0.822**	0.791**	0.774**
X2		--	0.410**	-0805	0.981**	-0.894**	0.798**	0.915**
X3			--	-0.473**	0.445**	-0.745**	0.367*	0.185*
X4				--	-0.888**	0.782**	-0.699**	-0.697**
X5					--	-0.888**	0.816**	0.885**
X6						--	-0.645**	-0.745**
X7							--	0.689**
X8								--

** - P.01   * - P.05

X1	SPECIFIC LEAF AREA
X2	LEAF AREA PER PLANT
X3	LEAF AREA INDEX
X4	SPECIFIC LEAF WEIGHT
X5	CROP GROWTH RATE
X6	NET ASSIMILATION RATE
X7	RELATIVE WATER CONTENT
X8	YIELD PER PLANT

TABLE 21. SIMPLE CORRELATION OF AVAILABLE MEDIA AND PLANT NUTRIENT CONTENT WITH YIELD

	X1	X2	X3	X4	X5	X6	X7
X1	--	0.533**	-0.255	0.899**	0.646**	0.795**	0.829**
X2		--	0.312*	0.663**	0.824**	0.790**	0.597**
X3			--	-0.072	0.178	0.092	0.023
X4				--	0.781	0.930**	0.849**
X5					--	0.873**	0.457**
X6						--	0.785**
X7							--

** - P.01   * - P.05

X1	AVAILABLE MEDIA NITROGEN
X2	AVAILABLE MEDIA PHOPHOROUS
X3	AVAILABLE MEDIA POTASSIUM
X4	PLANT NITROGEN
X5	PLANT PHOSPHOROUS
X6	PLANT POTASSIUM
X7	YIELD PER PLANT

The plant height (0.372), days to 50 per cent flowering (0.350), fruit setting percentage (0.363), total sugars (0.272) recorded a positive and significant correlation with total plant yield. The flower clusters per plant (0.778), flowers per cluster (0.792), fruit cluster per plant (0.560), fruits per cluster (0.727), single fruit weight (0.543), polar diameter of the fruit (0.589), equatorial diameter of the fruit (0.608), titrable acidity (0.577) and ascorbic acid content (0.613) recorded a high and positive significant correlation with total plant yield.

Fruit firmness (-0.441) and total soluble solids (-0.310) recorded a negative and significant correlation with total plant yield.

Physiological parameters viz., specific leaf area (0.774), leaf area per plant (0.915), crop growth rate (0.885), and relative water content (0.689) reported high and significant positive correlation with total plant yield. Leaf area index (0.185) reported a positive and significant correlation with total yield. Specific leaf weight (-0.697), and net assimilation rate (-0.745) reported a high and negative significant correlation with total yield.

Among media and nutrient analysis, available nitrogen (0.829), available phosphorus (0.597), plant nitrogen (0.849), plant phosphorus (0.457) and plant potassium (0.785) content were reported to be having high and positive significant correlation with total yield. Available potassium content (0.023) reported a positive correlation with yield.

Discussion

CHAPTER V

DISCUSSION

Greenhouse tomatoes need specific cultural requirements, which are different from field grown tomato. Tomato is one of the most important horticultural crops to produce with many procedures that must be followed to ensure healthy and productive crop. The selection of suitable variety, medium, correct spacing, optimum cultural practices like irrigation, fertigation, mulching etc. play important role in successful cultivation of greenhouse tomatoes. Relatively little effort has been made in developing a suitable package of practice for hybrid tomato under greenhouse in Tamil Nadu.

Many crop species are damaged by unfavourable weather conditions like high or low temperature, high rainfall etc. during critical phases of crop growth. Though greenhouse cultivation comes to rescue from such deleterious weather situations, the performance of the crop differs under different cultural practices. Understanding of such variations exhibited by tomato hybrids under various cultural practices and in two different seasons will enhance the possibility of selection of the best package of practices exclusively for greenhouse tomato.

Vegetables have continuous expression of reproductive phase after a certain period of juvenile growth. The flower bud differentiation, anthesis, fruit set and harvest are continuous over a period of crop growth; thereby they become sensitive to any external abiotic stress over this period. The difference in performance of tomato hybrid by manipulation of external environment through alterations in growing conditions is to be studied right from the seed germination up to anthesis as well as post-pollination events like fertilization and fruit set in each and every truss of tomato crop.

In the present investigation, the performance of an indeterminate tomato hybrid SH 7611 was assessed under greenhouse condition with the popular hybrid Arka Abijith for quantitative, biochemical, and physiological parameters through the experimental results in summer and kharif seasons and are discussed below.

5.1. Evaluation of tomato hybrid based on mean performance

5.1.1. Quantitative characters

5.1.1.1. Plant height

In summer and kharif seasons, the maximum plant height was recorded in T_{12} and the lowest in T_5. Among the growing media treatments, the plant height was maximum recorded in Soil: Compost: Coco peat (2:1:1). The best treatments in terms of yield viz., T_6 and T_{10}, registered higher plant height and hence plant height could have a positive association with yield in such indeterminate hybrids. These observations are in accordance with El- Aidy *et al.* (1988), Eltez (1994) and Celikel (1997), who reported that plant growth had significant and positive correlation with yield in indeterminate tomato F1 hybrid. The plants in the treatments viz., T_5, T_7, T_8 and T_{11} recorded lower plant heights except for the treatment T_{12} (Fig.1). The higher plant height observed in T_{12} might be due to the reduced spacing however it affected the yield due to higher crop competition. This is in accordance with Papadopoulose and Pararajasingham (1997), who reported that the increase in plant height with closer spacing is due to the increase in inter-nodal length as a result of

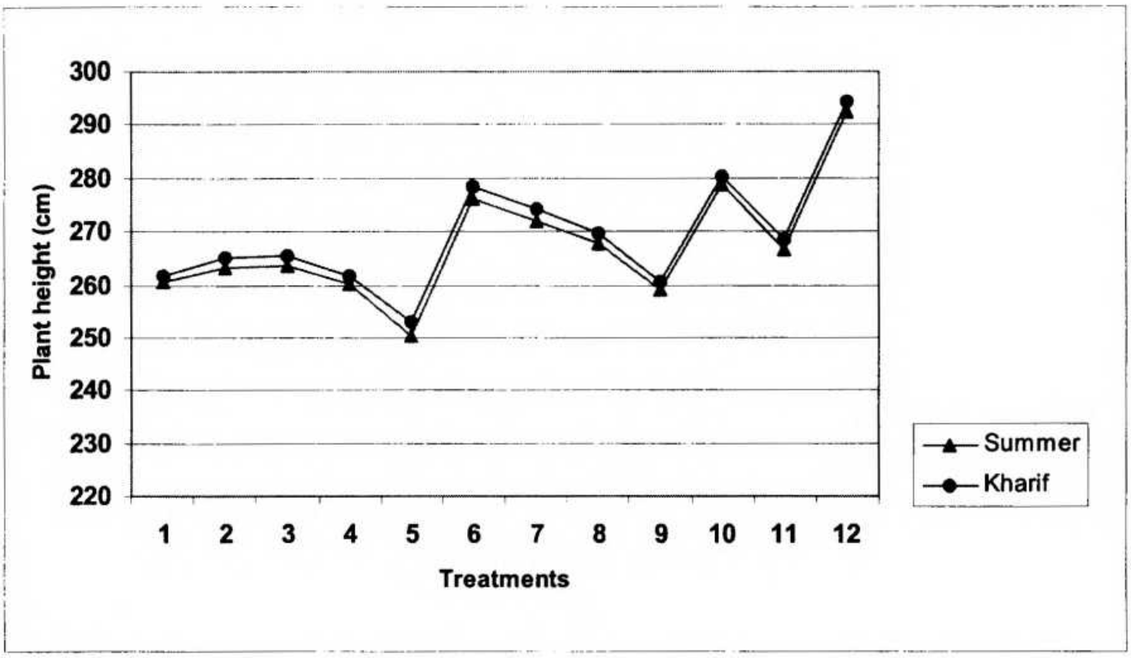

Fig.1. Mean performance of hybrids for plant height (cm) during summer and kharif

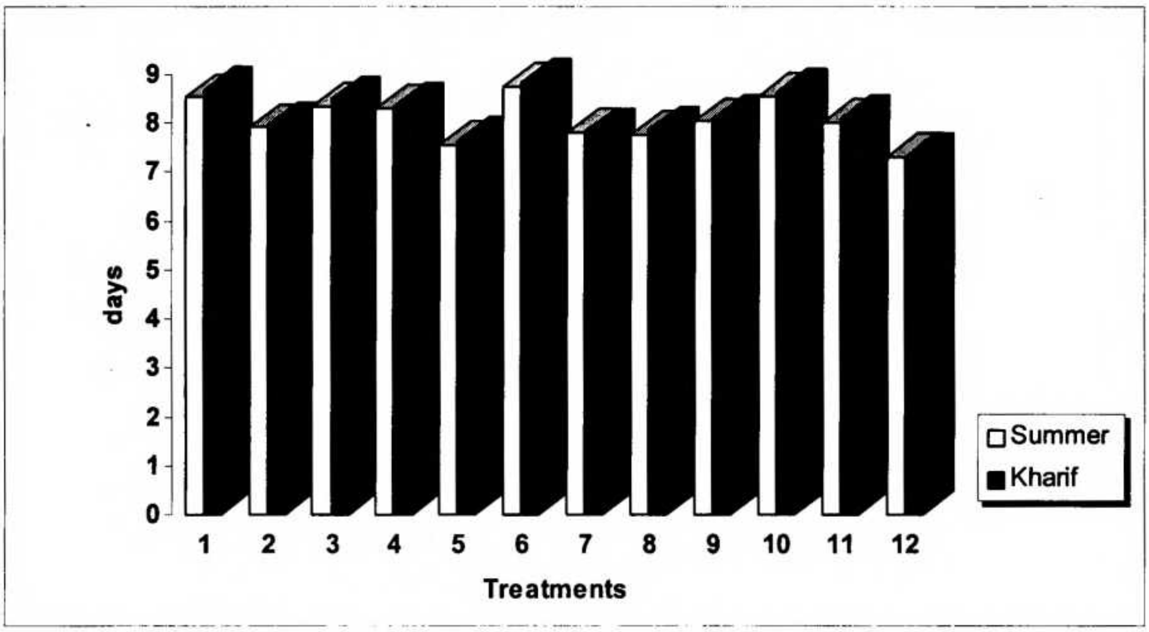

Fig.2. Mean performance of hybrids for days to 50 per cent flowering during summer and kharif

competition between the plants. The hybrid Arka Abijith had on par performance with SH 7611 under the treatment T_1. The mean height of the plants observed in summer season was lower than under kharif season. This reduction in height could be attributed to the negative effect of heat stress (Aruna , 1992; Rao and Sree vijayapadma, 1991).

5.1.1.2. Days to 50 per cent flowering

Earliest flowering was observed in T_{12} in both the seasons while late flowering was recorded in T_9. Among the growing media treatments, earliest flowering was observed in Soil: Compost: Sand (2:1:1) and this may probably due to better root activity aided by sand. The better performing treatments in terms of yield viz., T_6 and T_{10} were found to be late in flowering, whereas the plants in treatments like T_5, T_7, T_8, T_{11} and T_{12} were found to be earlier in 50 per cent flowering (Fig. 2). This shows a negative relationship between earliness with yield. Probably the yield becomes source limited in early flowering treatments. Because of insufficiency of source and transformation to reproductive phase these treatments would not supply sufficient photosynthates for the developing sinks. In those treatments where the source was not limiting, the availability of photosynthates would have been sufficient to put forth more number of flowers as to meet the demand of flowers produced there by the yield would have been better. These observations are in accordance with Gent (1992), and Lohar and Peat (1998), who observed that when plants were subjected to stress like drought, high temperature, competition between plants etc. after putting forth vegetative growth, they readily entered into reproductive phase. Aruna and Veeraragavathatham (1997) also observed negative association for this trait with yield. These observations are further confirmed by the late flowering observed in kharif season commensurating with better performance of all treatments in terms of yield compared to summer season. The standard hybrid Arka Abijith was late in flowering.

5.1.1.3. Number of flowers

In summer and kharif, the highest number of flower clusters per plant and flowers per cluster were registered in T_6 and lowest in T_{12}. Among the growing media, highest flower number was found in Soil: Compost: Sand (2:1:1). The plants in treatments T_5, T_7, T_8, T_{11} and T_{12} performed poorly in producing adequate number of flowers in both the seasons compared to control. The standard hybrid Arka Abijith was also observed to contain less number of flowers compared to SH 7611 under T_1 (control). The biofertilizer treatments viz., T_6 and T_{10} were found to excel in having more number of flowers compared to all the other treatments (Fig. 3 and 4). This confirms the positive correlation of number of flowers with yield. In general kharif-grown crop performed well interms of number of flowers compared to summer. These observations confirm the observations of Kalloo (1989) and Papado poulose (1998) who had reported that a reduction in number of flowers was a common observation in stress-influenced plants. The better performance of T_6 and T_{10} was attributed to the enhancing effect of bio- fertilizers on the performance of tomato in terms of number of flowers.

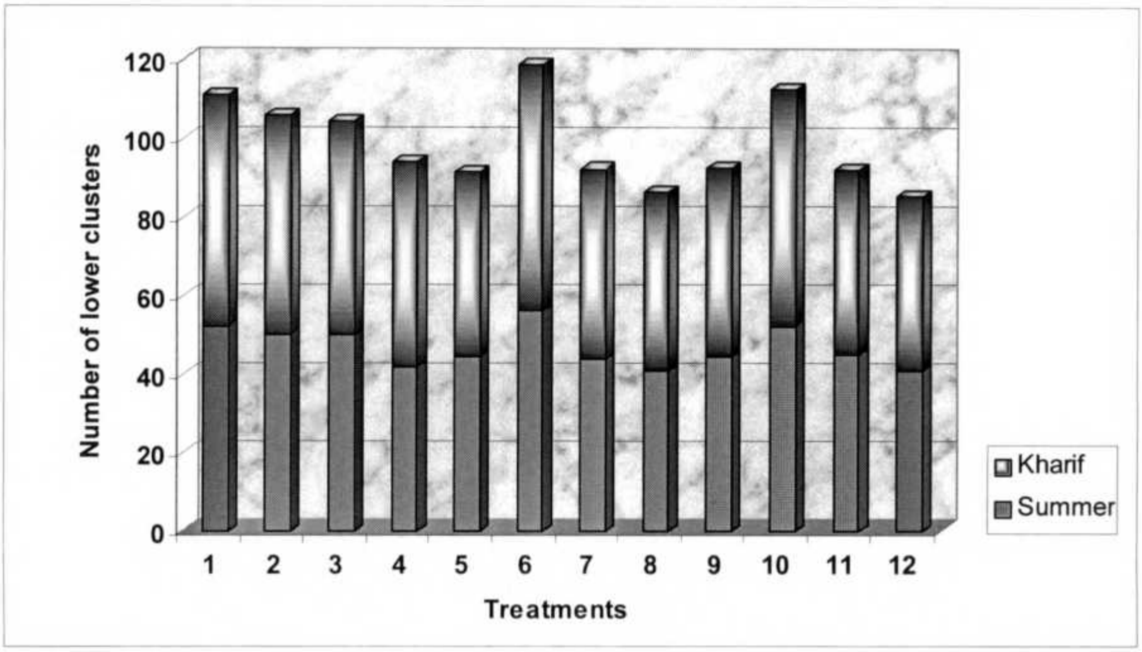

Fig.3. Mean performance of hybrids for flower clusters per plant during summer and kharif

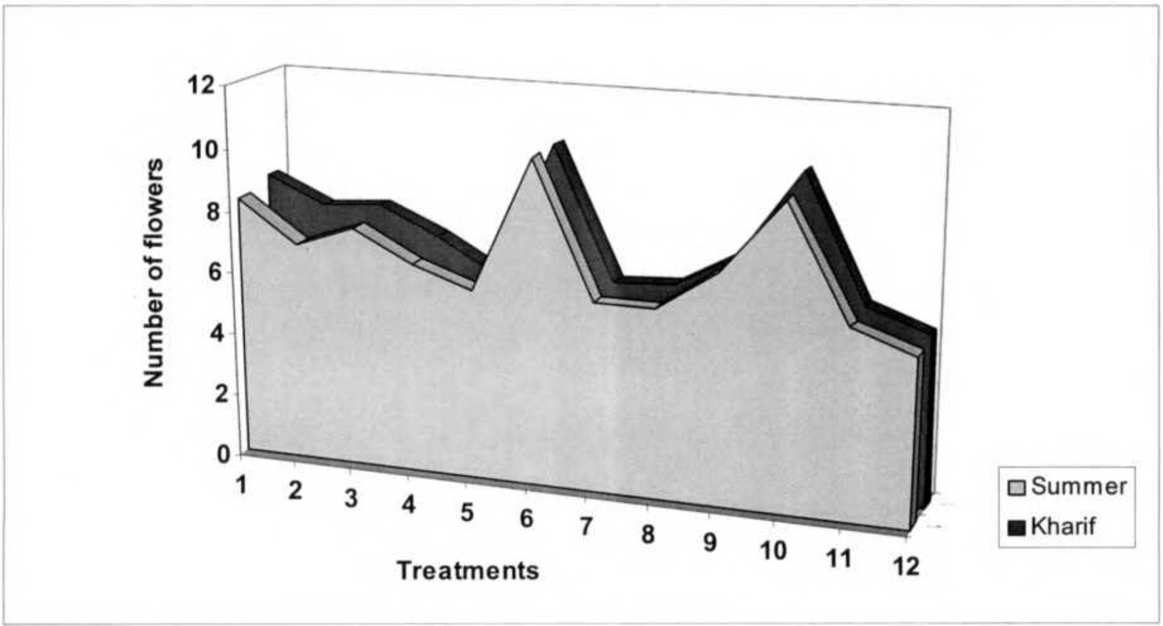

Fig.4. Mean performance of hybrids for flowers per cluster during summer and kharif

5.1.1.4. Fruit setting percentage

In kharif and summer, among all the treatments, the best fruit set was observed in T_1 and lowest in T_{12}. T_1 with growing media of soil-compost-sand in the ratio 2:1:1 was better in enhancing the fruit set in greenhouse tomato compared to all other media. T_5 with irrigation regime of 40 Kpa, T_7 of fertigation with straight fertilizers, T_8 without mulching, T_{11} with topdressing of NPK fertilizers and T_{12} with reduced spacing, were found to have low fruit set compared to control. The better performing treatments in terms of yield viz., T_6 and T_{10} were found to have a fruit setting percentage on par with control (T_1) (Fig. 5) This observation confirms the reports of Varga *et al.* (2000), who reported that optimum cultural condition resulted in higher fruit set in greenhouse tomato. The negative effect of stress on fruit set in greenhouse tomato confirms the reports of Papado poulose (1998), who observed detrimental effect of close spacing on fruit set of greenhouse tomato which was due to the inadequate supply of photosynthates to the plant stand. The reduction in fruit set, observed in summer season, may be due to the negative effect of water stress as found by Veit kohler *et al.* (2001).

5.1.1.5. Fruits per plant

In kharif and summer, the highest number of fruiting clusters and fruits per cluster were found in T_6 and lowest in T_{12}. Among the growing media treatments, the highest number of fruits was found in T_3. T_5 with irrigation regime of 40 Kpa, T_7 with fertigation of straight fertilizers, T_8 without mulching, T_{11} with topdressing of NPK fertilizers and T_{12} with reduced spacing, were found to have low number of fruits compared to control. The standard hybrid Arka

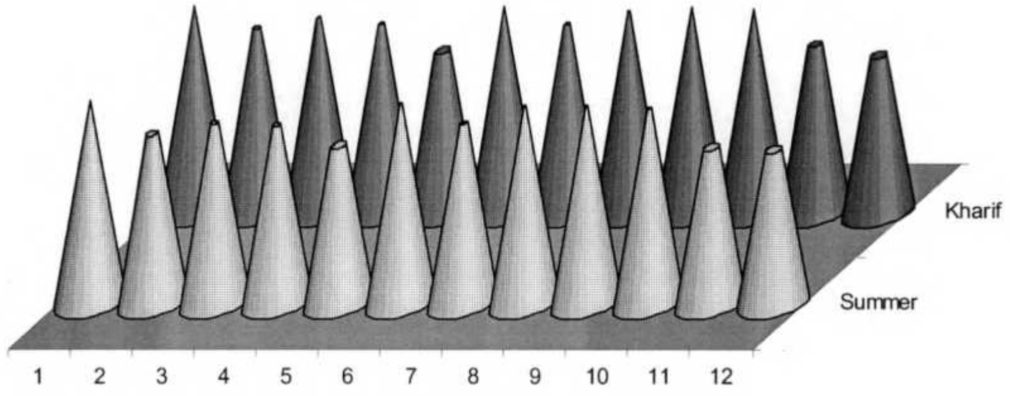

Fig.5. Mean performance of hybrids for fruit setting percentage during summer and kharif

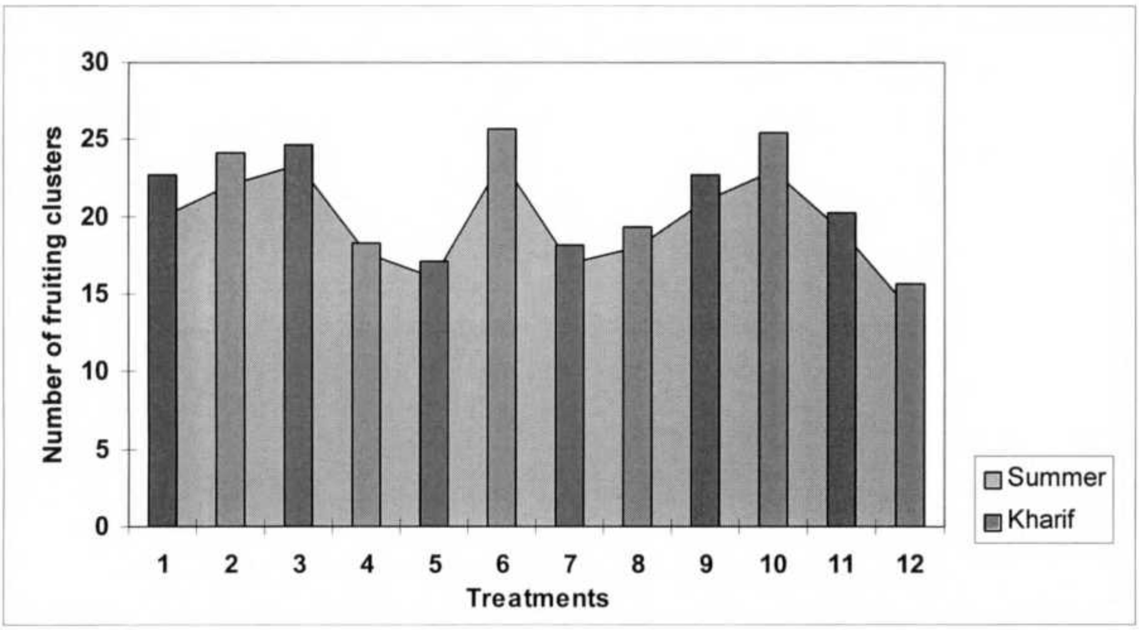

Fig.6. Mean performance of hybrids for fruiting clusters per plant during summer and kharif

Abijith was observed to contain same number of fruits with control. The biofertilizer treatments viz., T_6 and T_{10} were found to excel in having more number of fruits compared to all the other treatments (Fig 6 and 7). In the treatments T_6 comprises of basal application of K @ 50 kg ha^{-1} + biofertilizers and in T_{10} with all the three nutrients + biofertilizers, the phosphobacteria would have made more P available (by converting unavailable P in to available one) there by would have encouraged early growth of roots. The phosphorus would have also encouraged more fruit set. P is one of the important essential elements required for fruit set. Phosphorus supplied through fertigation would have been made available by phosphobacteria, which in turn would have been used in better fruit set. These observations confirm the reports of Alan and Zulkadir (1994), Servetvaris and Tancerozyyaman (1994), Calabretta and Nucifora (1994), Mokrzecka (2000) and Yau and Murphy (2000), who had reported an enhancing effect of organic growing media combined with inorganic fertilizers in increasing the number of fruits in greenhouse tomato. The detrimental effect of water stress on number of fruits in T_5 is explained by the observations of *Xu et* al., (1995). T_{12} with reduced spacing was found to have a lower number of fruits compared to control due to greater crop competition. This is in accordance with Boztok and Gul (1992), who found that the closer spacing have detrimental effect on number of fruits in greenhouse tomato. In general, plants performed well in terms of number of fruits in kharif than in summer. The better performance of plants in kharif may be due to the congenial conditions prevailed during the period (Arunkumar, 2000).

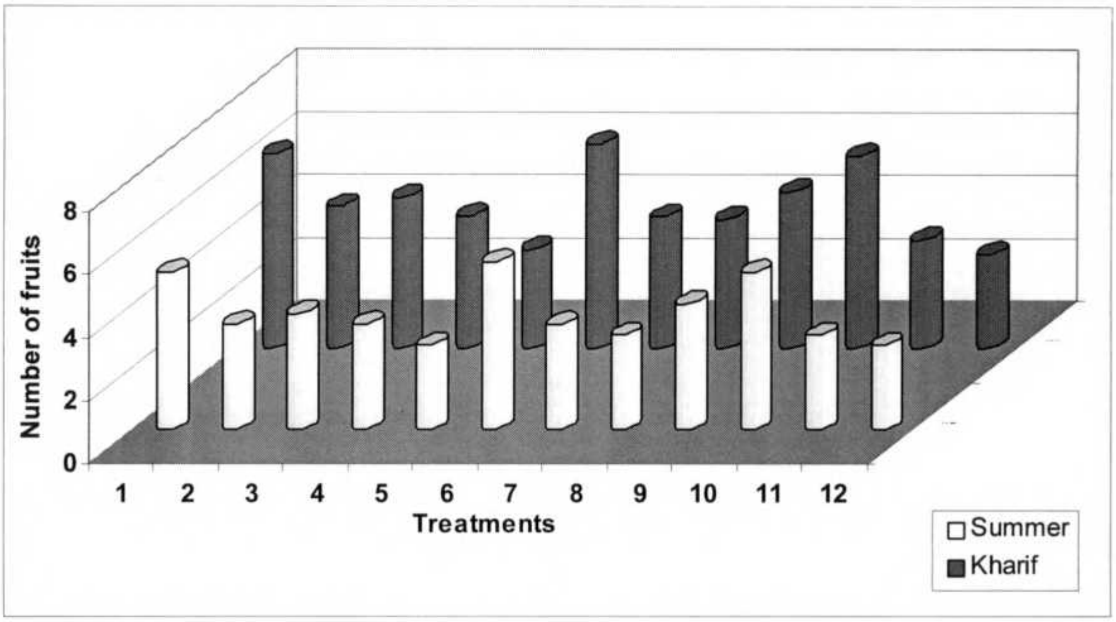

Fig.7. Mean performance of hybrids for fruits per cluster during summer and kharif

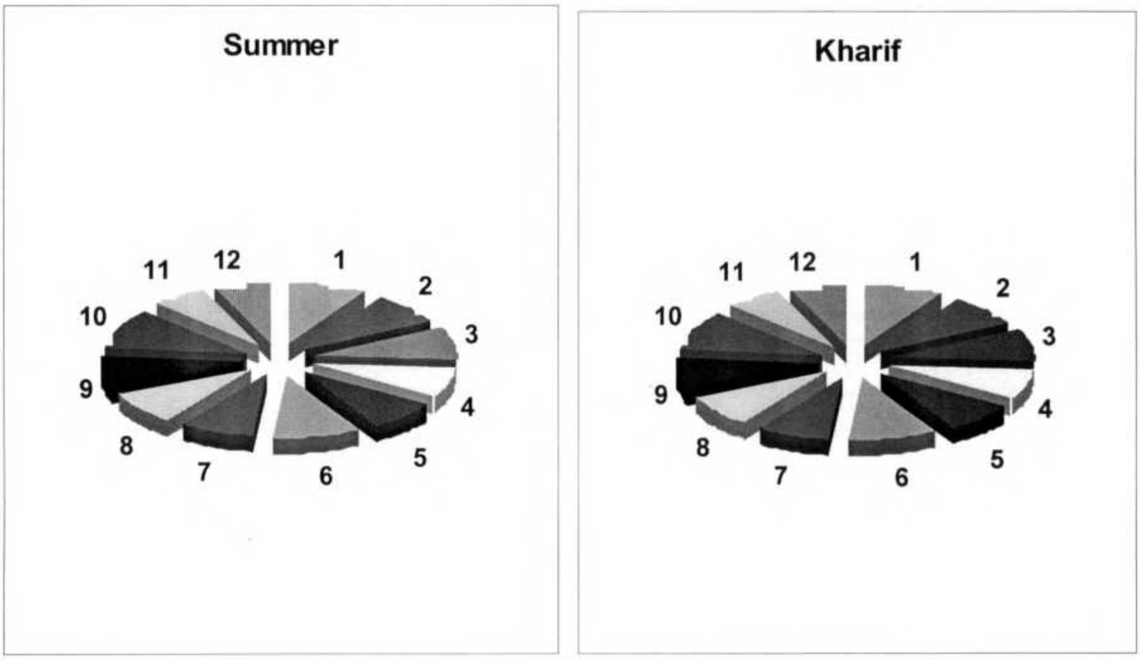

Fig.8. Mean performance of hybrids for single fruit weight (g)

5.1.1.6. Fruit weight

The biofertilizer treatments viz., T_6 and T_{10} were found to have the highest fruit weight compared to all other treatments. T_{12} with reduced spacing recorded the lowest value for single fruit weight. Among the growing media comparisons, the treatment with growing media of soil-compost-sand in the ratio 2:1:1 (T_1) obtained the highest value for single fruit weight. These two treatments had biofertilizers as one of the components. These would have supplied more nitrogen and phosphorus, which are essential for protein synthesis to help in improvement of fruit size and fruit weight. This observation is in accordance with Baskar and Saravanan (1998), who observed an increase in single fruit weight of greenhouse tomato with organic growing media. T_5 with irrigation regime of 40 Kpa, T_7 with fertigation of straight fertilizers, T_8 without mulching, T_{11} with topdressing of NPK fertilizers and T_{12} with reduced spacing, were found to have low single fruit weight compared to control. This confirms the various observations of Alan and Zulkadir (1994), Servetvaris and Tancerozyyaman (1994), Sharma *et al.* (1994), Pakyurek (1994), Tekinel (1994), Siwek et al., (1994), Papapdapoulose and Pararajasingham (1997) and Ymeri *et al.* (2000). The standard hybrid Arka Abijith found a low fruit weight compared to SH 7611. In general, the hybrids performed well in terms of single fruit weight in kharif season than in summer (Fig 8). The high performance of tomato hybrids may be due to the favourable environment for its growth in kharif as observed by Arunkumar (2000).

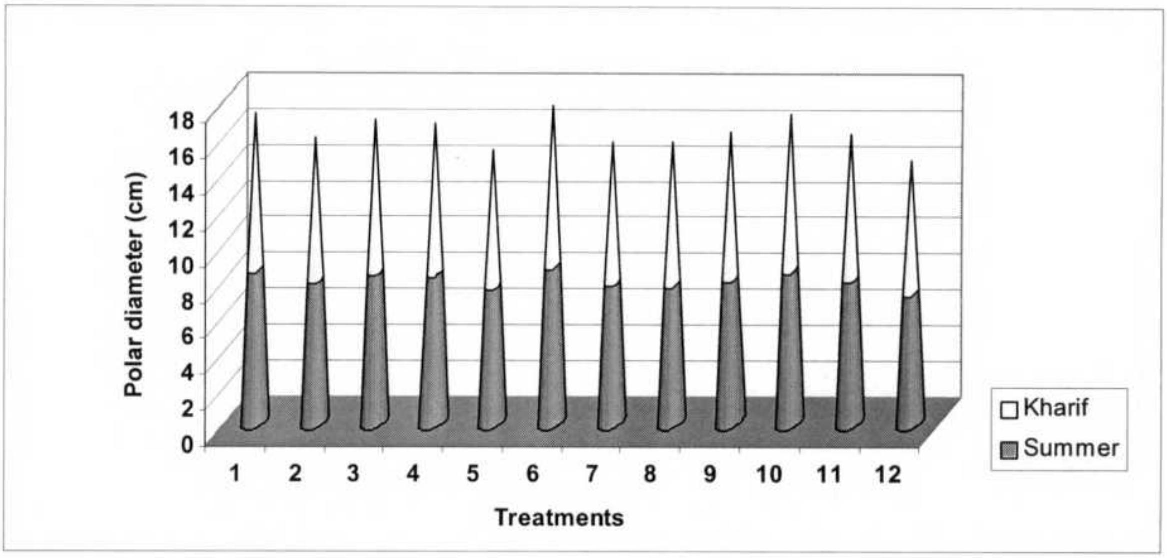

Fig.9. Mean performance of hybrids for polar diameter (cm) during summer and kharif

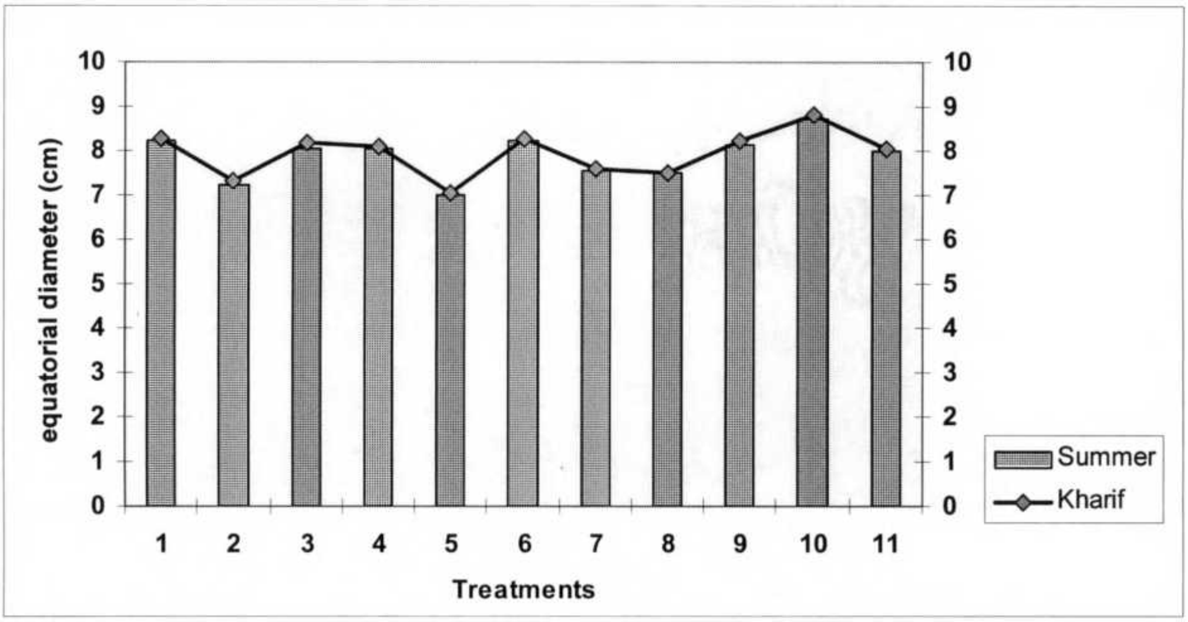

Fig.10. Mean performance of hybrids for equatorial diameter (cm) during summer and kharif

5.1.1.7. Fruit size

Fruit size in terms of polar diameter and equatorial diameter were found to be high in biofertilizer treatments viz., T_6 and T_{10}. Between T_6 and T_{10}, the polar diameter was found to be high in T_6, where as T_{10} was found to have higher equatorial diameter. T_1 with soil-compost-sand in the ratio 2:1:1 obtained the highest fruit size among the growing media comparisons. This result is in accordance with Gul and Sevgican (1994), who found a significant difference in single fruit weight among different media comparisons. T_5 with irrigation regime of 40 Kpa, T_7 with fertigation of straight fertilizers, T_8 without mulching, T_{11} with topdressing of NPK fertilizers and T_{12} with reduced spacing, were found to have low value for single fruit size compared to control. In general, both the hybrids performed well in fruit size under kharif conditions than in summer (Fig 9 and 10). The standard hybrid Arka Abijith had a lower fruit size compared to SH 7611. These observations confirm the findings of Tuzel and Ul (1994), who recorded a linear increase in fruit size with higher amount of irrigation water, Pakyurek (1994), who found an increase in fruit diameter of greenhouse tomato grown with transparent mulch, Sharma *et al*, (1994), who registered an increase in fruit size of tomato grown with fertigation of nitrogen and phosphorus and Papdapoulose and Pararajasingham (1997), who found a decrease in fruit size with narrow spacing.

5.5.1.8. Fruit yield

In both kharif and summer, T_6 and T_{10} in which the plants are fertigated using NPK and supplemented with biofertilizers, excelled in fruit yield per plant and estimated fruit yield per hectare. Among the bio fertilizer treatments, T_6

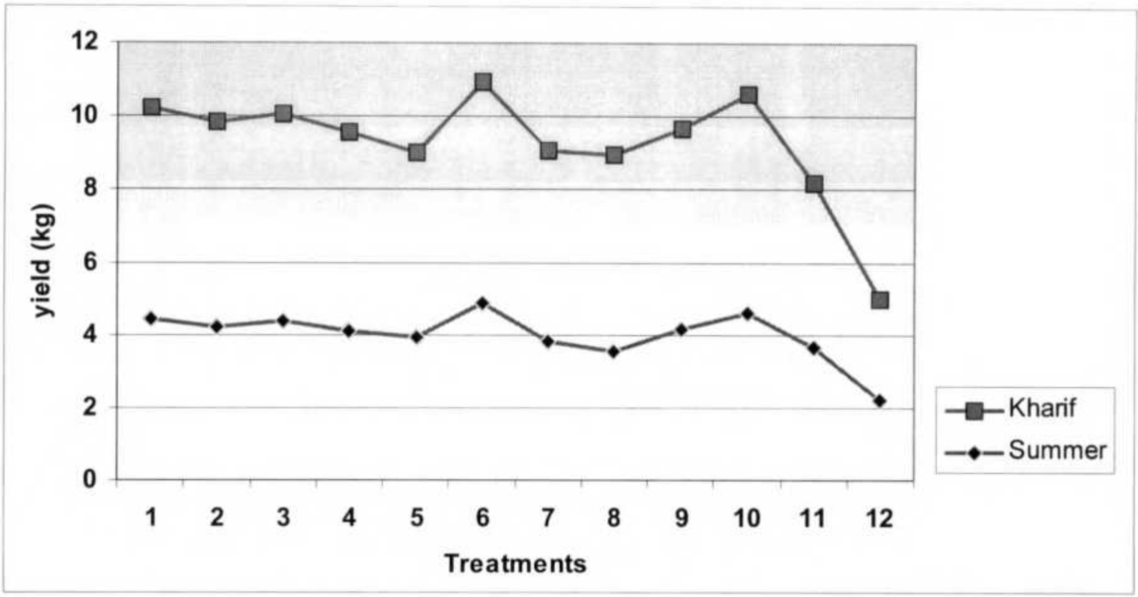

Fig.11. Mean performance of hybrids for yield per plant (kg) during summer and kharif

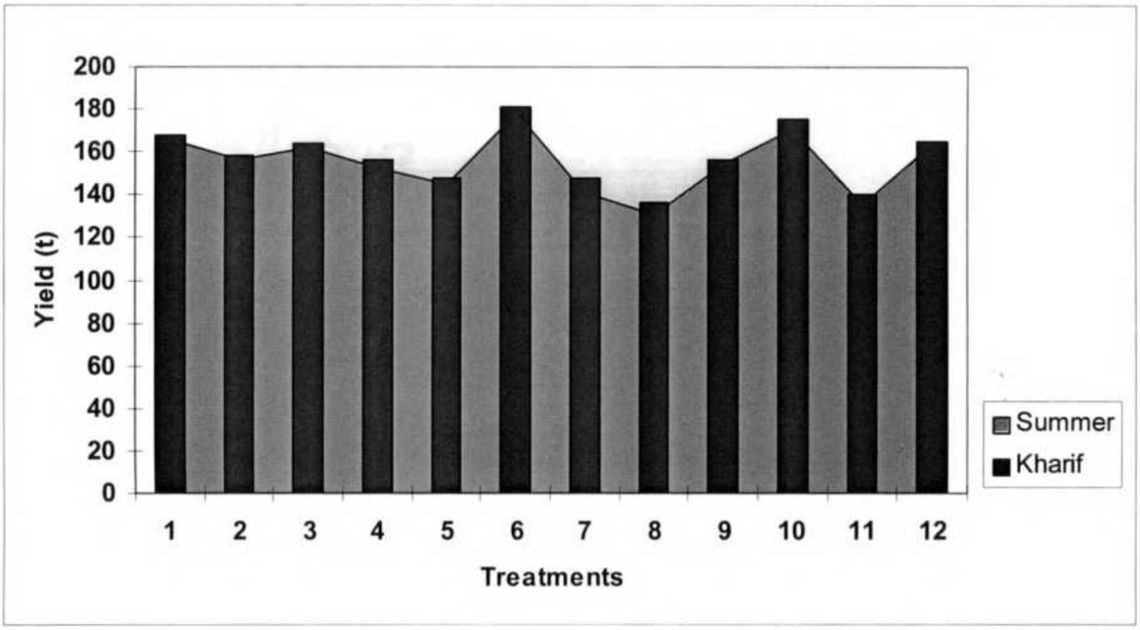

Fig.12. Mean performance of hybrids for yield per ha (t) during summer and kharif

with biofertilizers and K fertilizer as basal recorded the maximum yield and was slightly higher than T_{10} with biofertilizers and NPK fertilizers as basal. This may be due to the supplementation of nitrogen and phosphorus requirement of the crop by azospirillum and phosphobacteria respectively and potassium requirement by basal application of inorganic K fertilizer. Even though T_{10} was also provided with the same cultural conditions in addition to the inorganic N and P fertilizer as basal, it has not performed to the extent of T_6 (Fig. 11 and 12), which may be attributed to the excessive vegetative growth than those plants in T_6, as seen in the respective physiological observations (leaf area per plant and crop growth rate), and corresponding reduction in reproductive growth. Among the growing media treatments, the highest fruit yield was found in growing media of soil-compost-sand in the ratio 2:1:1. This may be due to the better performance of plants under biofertilizers in terms of number of flowers and fruit setting percentage compared to all other treatments. This confirms the observations of Alan and Zulkadir (1994), who reported that growing media had significantly influenced the yield of greenhouse tomato and obtained the maximum yield when grown with a combination of pumice, peat and perlite in the ratio 2:1:1. The treatment T_{12} with reduced spacing of 30×22.5 cm obtained the lowest fruit yield per plant, but its performance in terms of fruit yield per ha was on par with control and this is attributed to the higher number of plants due to reduced spacing (Papdapoulose and Pararajsingham, 1997).

With irrigation regime of 40 Kpa (T_5), the plants performed poor in total fruit yield compared to control and this may be due to the low number of flowers and low fruit setting percentage as a result of water stress. This is in accordance with Tuzel and Ul (1994), who found that total yield (number of fruit/m²) of greenhouse tomato had positive correlation with amount of irrigation water and water use of the plant. T_7 with fertigation of straight fertilizers also recorded a low fruit yield compared to control and this showed the advantage of water-soluble fertilizers over straight fertilizers in fertigation of greenhouse tomato (Papadopoulos, 1998; Alcanter *et al.*, 2000). T_8 without mulching also found to be lagging behind in total fruit yield compared to control, and this clearly shows the advantage of polythene mulching over non mulching (Tuzel and Ul, 1994). T_{11} with top-dressing of fertilizers performed inferior to control with fertigation and this is in accordance with findings of Papadopoulos (1998), Baskar and Saravanan (1998), Carrijo and Hochmuth (2000) who had observed a boosting effect on greenhouse tomato yield by fertigation with water-soluble fertilizers compared to conventional fertilizer applications.

In general, hybrids performed well in kharif than in summer as already seen and which may be due to the favourable environment during kharif compared to summer which helped the hybrids to perform better in terms of number of flowers, fruit setting percentage, number of fruits, fruit weight and size. When compared to the standard hybrid Arka Abijith, fruit yield was significantly higher in the hybrid SH 7611 under favourable treatments.

5.1.2. Fruit quality

The microclimatic conditions that normally prevail inside the greenhouse i.e. relevant thermal excursion, lesser light intensity, and other growing conditions can greatly affect the quality of the fruits (Forshey and Alban, 1954).

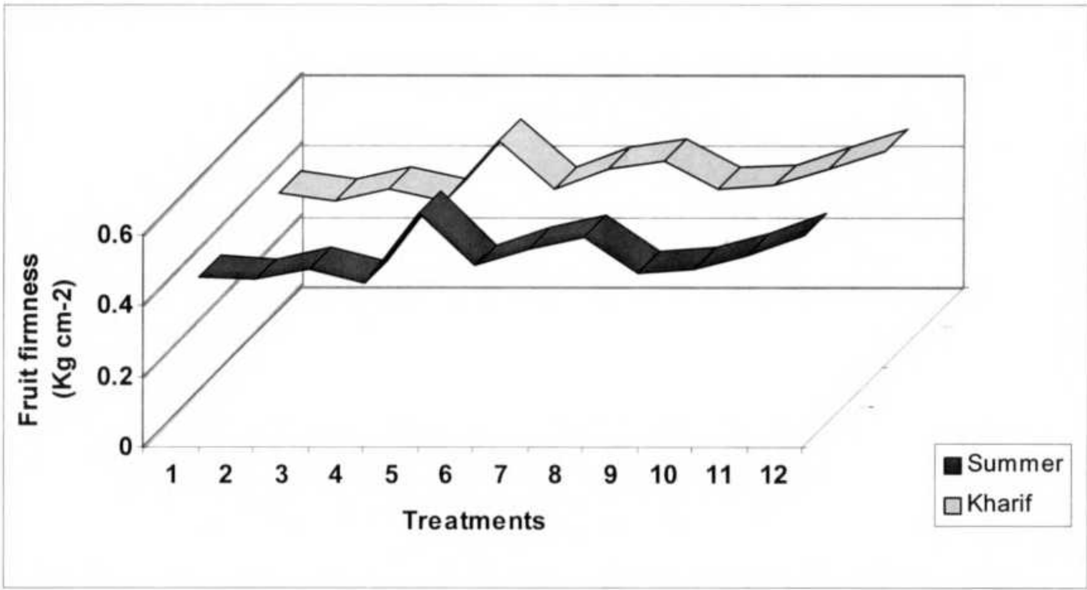

Fig.13. Mean performance of hybrids for fruit firmness (kg cm^{-2}) during summer and kharif

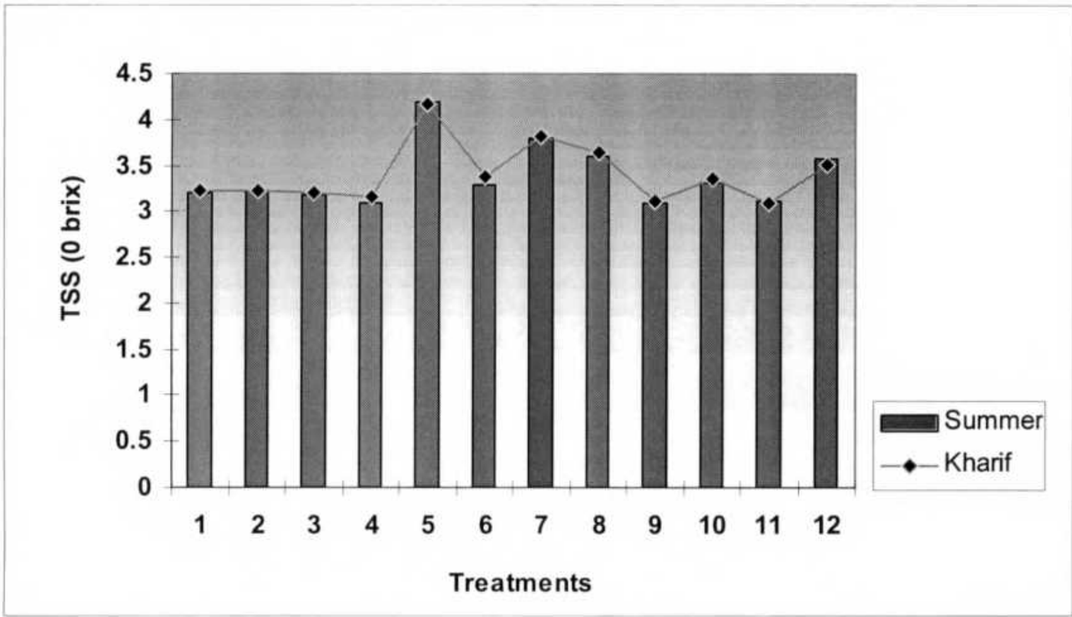

Fig.14. Mean performance of hybrids for total soluble solids (^{0} brix) during summer and kharif

In greenhouse, the reduced radiations that are normally registered, can modify titrable acidity, sugars and other parameters (Winsor and Adams, 1976). A wide range of variations was observed among treatments in fruit quality characters like T.S.S, titrable acdity, ascorbic acid, total sugars and fruit firmness. The variation between two seasons was also pronounced in fruit quality with plants performing better in kharif season. This may be due to the congenial condition prevailing during the kharif season for better growth of tomatoes even under greenhouse condition.

The highest TSS was found in T_5 with irrigation regime of 40 kpa and was higher in treatments T_7 with fertigation of straight fertilizers, T_8 without mulching, T_{11} with topdressing of NPK fertilizers and T_{12} with spacing 30×22.5 cm. The better performing treatments in terms of yield viz., T_6 and T_{10} were found to contain less total soluble solids in fruit (Fig. 14). This negative relationship of yield with TSS is attributed to the less water content and low conversion of starch to sugar in these treatments as found by Stevens *et al.*, (1978) and it may also be due to regular irrigation as been reported by Varga *et al.* (2000).

Total sugars content were highest in treatments T_1, T_6 and T_{10}. Even though the treatments T_5 (with irrigation regime of 40 kpa), T_7 (with fertigation of straight fertilizers), T_8 (without mulching), T_{11} (with topdressing of NPK fertilizers), and T_{12} (with spacing 30×22.5cm) recorded fairly high TSS, the total sugar content was found to be low due to the lower sugar conversion rate enhanced by the unfavourable cultural conditions in these treatments. In general, both the hybrids performed well in kharif than in summer as observed by Sharma and Tiwari (1993) (Fig. 15).

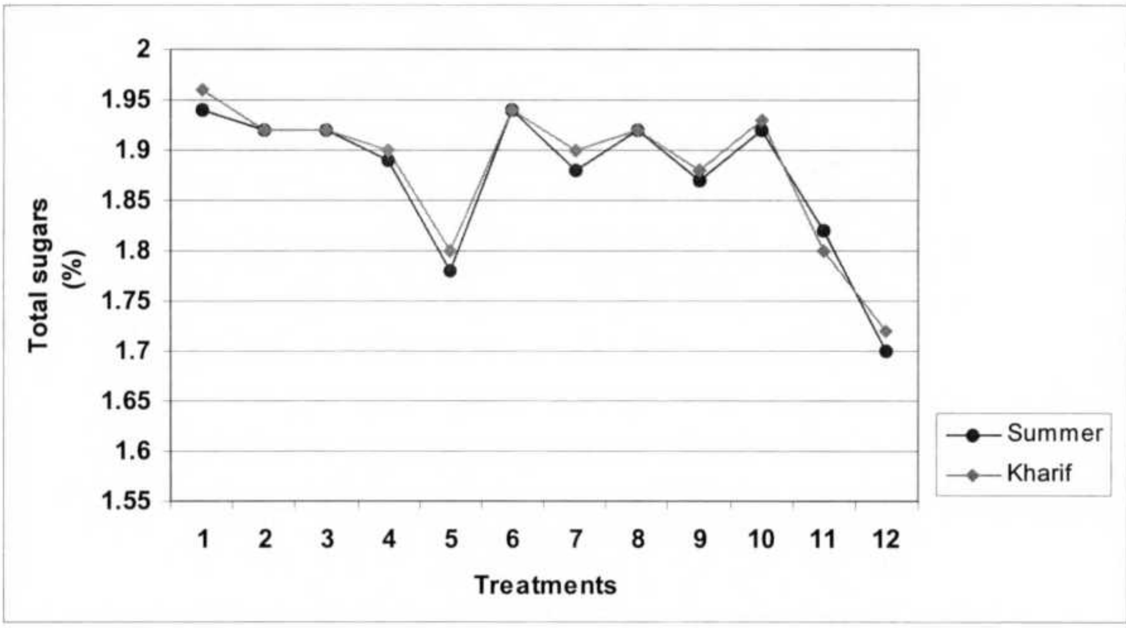

Fig.15. Mean performance of hybrids for total sugars content (per cent) during summer and kharif

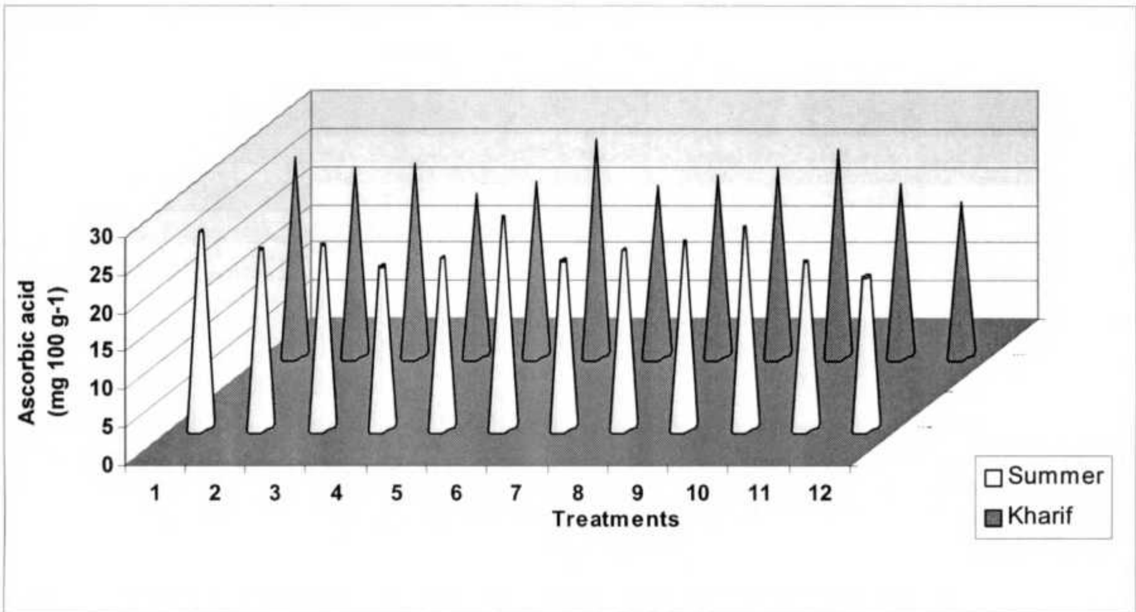

Fig.16. Mean performance of hybrids for ascorbic acid content (mg 100 g^{-1}) during summer and kharif

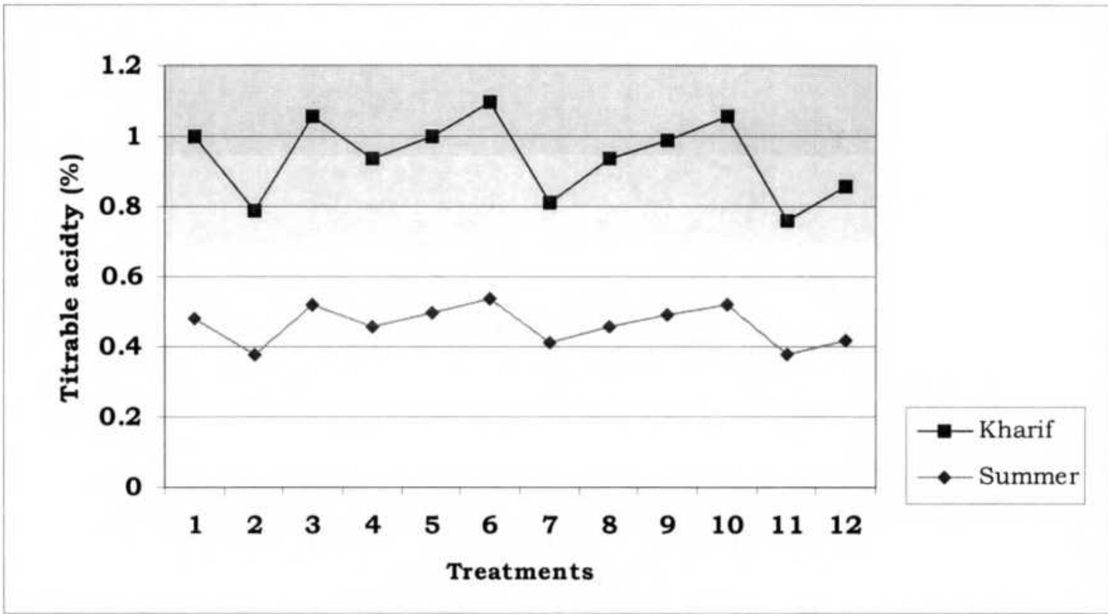

Fig.17. Mean performance of hybrids for titrable acidity (per cent) during summer and kharif

Total ascorbic acid content in the fruit was highest in T_6 followed by T_{10}. Among the growing media, the highest ascorbic content was found in T_1. The treatments like T_5, T_7, T_8, T_{11} and T_{12} were found to contain lower ascorbic acid. These results are in accordance with findings of Youssef *et al.* (2001), who had found that the organic matter and inorganic fertilizer combination helped to produce fruits with high vitamin C content. The hybrid SH 7611 had better ascorbic acid content over standard hybrid Arka Abijith. In general, both the hybrids performed well in kharif than in summer (Fig. 16).

Titrable acidity of the fruit was found to be higher in T_6 andT_{10}. T_5 with irrigation regime of 40 kpa was found to have higher titrable acdity compared to control and this was attributed to the decrease in amount of irrigation water. Increase in amount of irrigation favoured the moisture content of the fruit and had a dilution effect on the titrable acidity (Tuzel and Ul, 1994) (Fig. 17).

Fruit firmness, which indicates the toughness of a fruit, was found to be highest in T_5 with irrigation regime of 40 kpa. This observation confirms the findings of Tuzel and Ul (1994), who found that as irrigation rates are reduced, fruits with tough skin are obtained. The better performing treatments in terms of yield T_6 and T_{10} obtained a fruit firmness on par with control. Treatments T_8 and T_{12} also found to have a high fruit firmness (Fig. 13). This confirms the observations of Plaut and Grava (2000), that the tomato plants suffering from water stress developed better peel thickness. The higher fruit firmness exhibited by hybrids during summer confirms this observation.

5.1.3. Physiological observations

The highest leaf area per plant was found in T_{10} followed by T_6, which were the best treatments in terms of total yield. This gives the positive relation

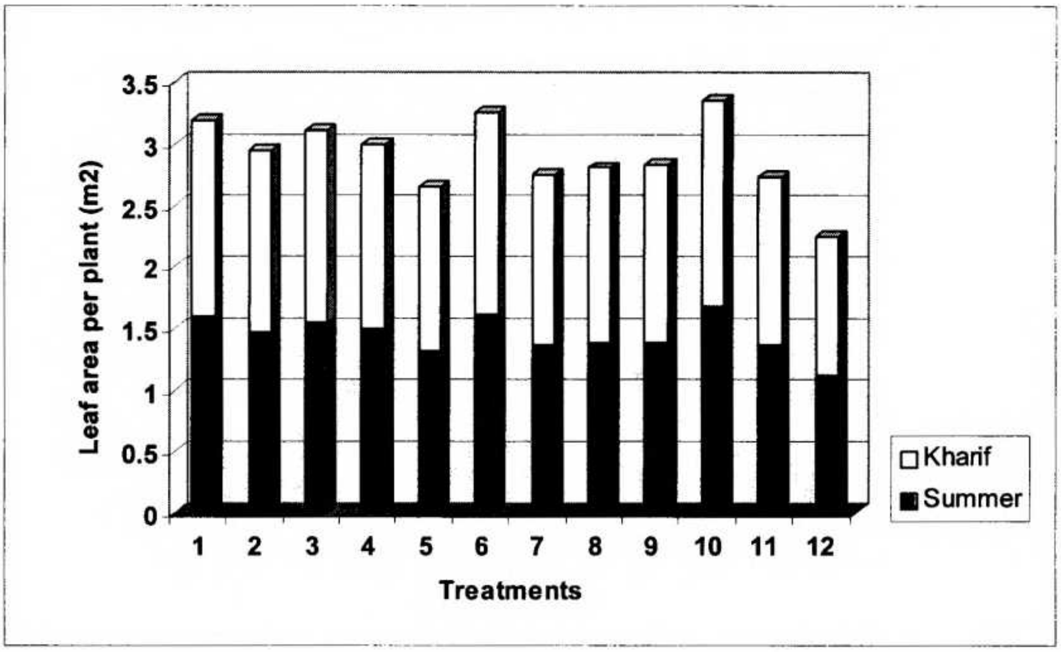

Fig.18. Mean performance of hybrids for leaf area per plant (m^2) during summer and kharif

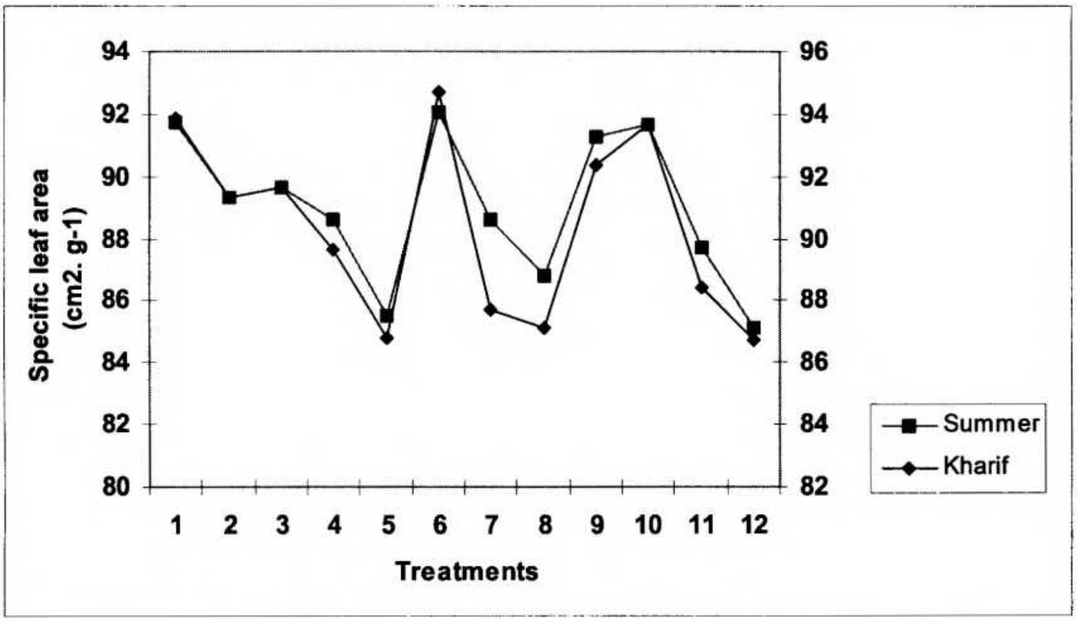

Fig.19. Mean performance of hybrids for specific leaf area ($cm^2\ g^{-1}$) during summer and kharif

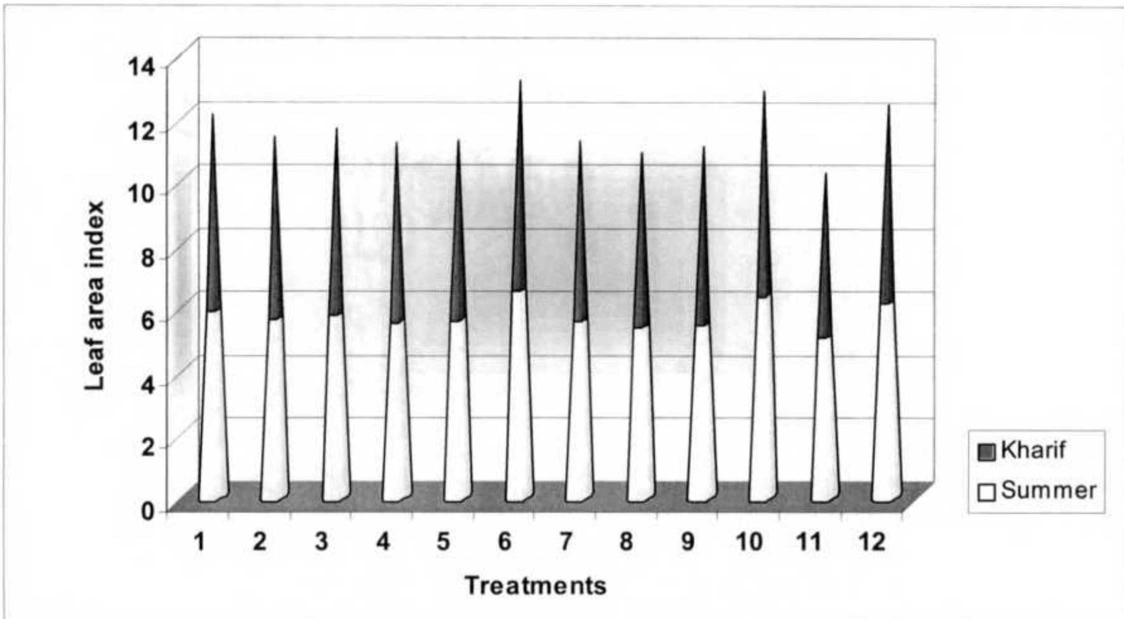

Fig.20. Mean performance of hybrids for leaf area index during summer and kharif

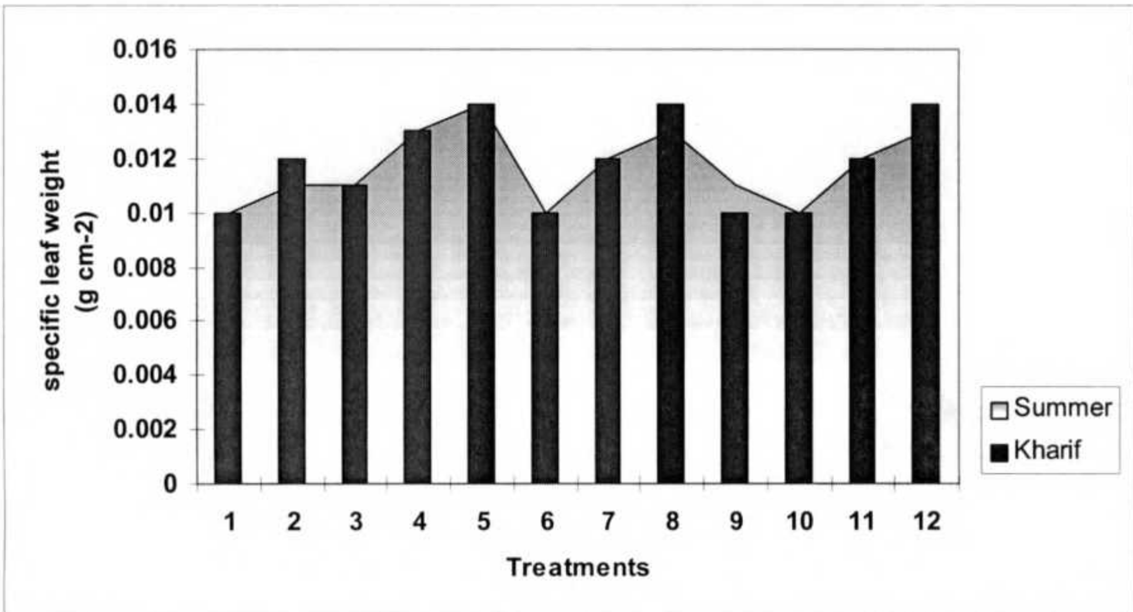

Fig.21. Mean performance of hybrids for specific leaf weight (mg cm^{-2}) during summer and kharif

of total leaf area per plant with total plant yield. But, the better performance of T_6 over T_{10} could be attributed to the optimal vegetative growth in T_6 when compared to T_{10} in which there was excessive vegetative growth at the expense of reproductive growth. The plants under the treatments T_5, T_7, T_8, T_{11}, and T_{12} were having less leaf area per plant and apparently performed poorly in total yield (Fig. 18). The leaf area index also followed the similar trend. The highest leaf area index was recorded in T_6 and T_{10} and showed a positive relation of LAI with plant yield (Fig. 20) The higher leaf area index observed in T_{12} was attributed to the reduced spacing which coincides with the observations of Papadopoulose and Pararajasingham (1997). In kharif, higher fruit yield in association with higher leaf area index was found (Boztok and Gul, 1992; Papadopoulose, 1998).

Specific leaf area, which gives an indication of effective photosynthetic area in comparison to the leaf weight, was found to be the highest in T_6 followed by T_{10} (Fig.19). These observations clearly indicate the positive correlation of specific leaf area with fruit yield (Papadopoulose, 1998). Specific leaf weight follows the opposite trend as that of specific leaf area. The highest specific leaf weight was found in T_5 (Fig.21). This increase in specific leaf weight was attributed to the water stress suffered by the plants under T_5. This confirm the observations of Rao *et al.,* (2000) who had found that under drought conditions tomato plants developed more leaf thickness in compensation for reduced leaf area.

Crop growth rate indicates the rate at which the plant is growing and this was found to be the highest in treatments T_6 andT_{10}. The higher crop growth rate recorded in T_6 and T_{10} was attributed to the increase in leaf area

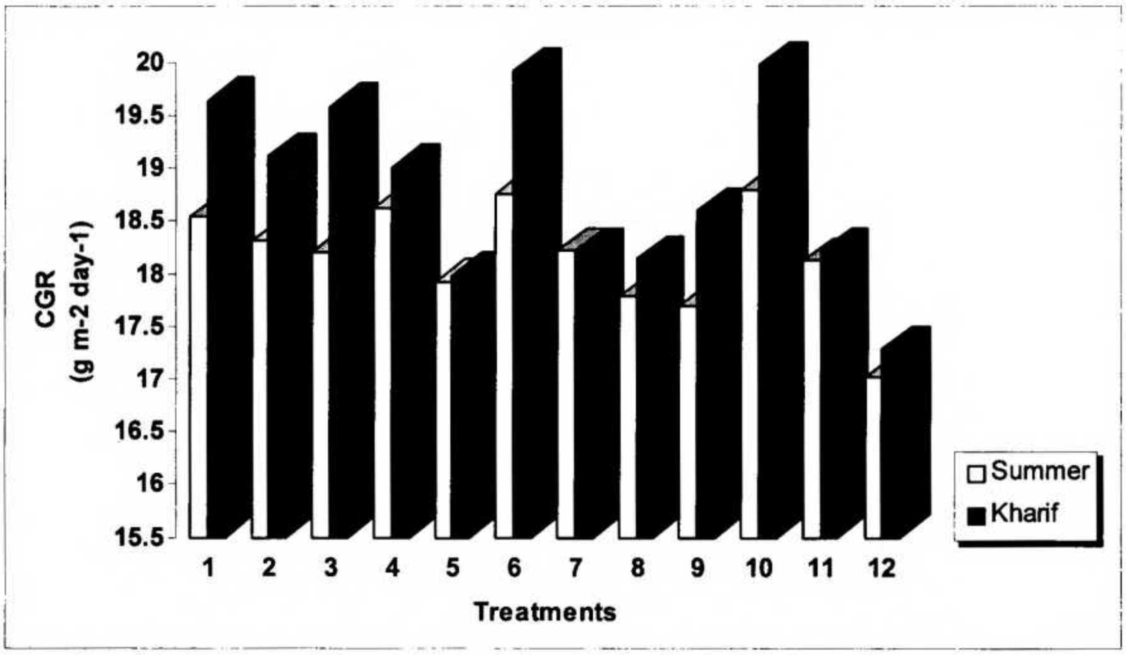

Fig.22. Mean performance of hybrids for crop growth rate (g m^{-2} day^{-1}) during summer and kharif

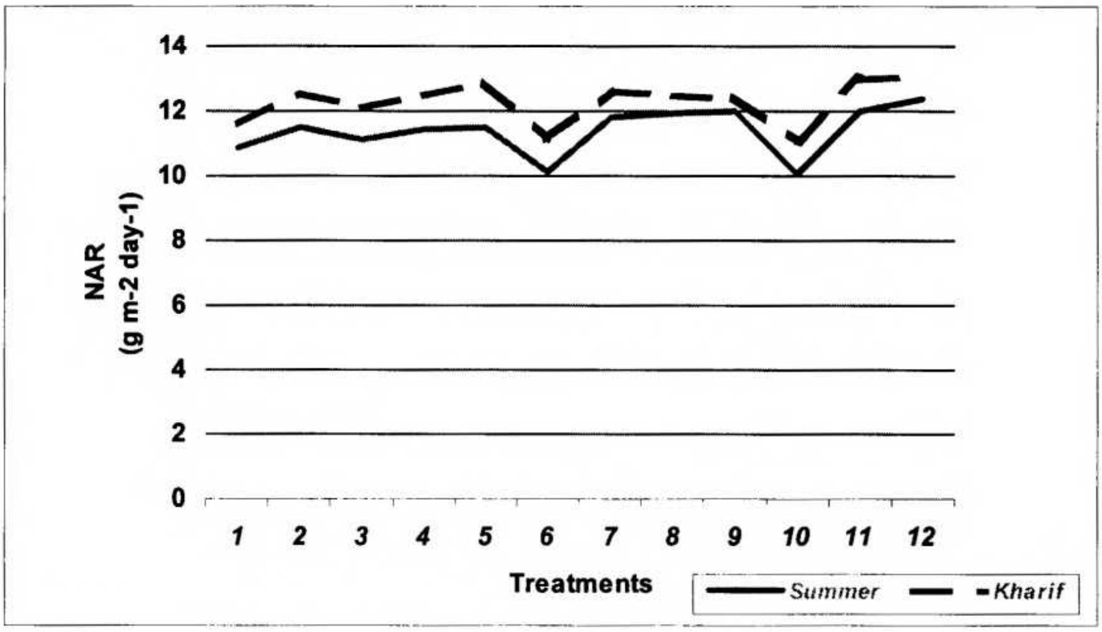

Fig.23. Mean performance of hybrids for net assimilation rate (g m^{-2} day^{-1}) during summer and kharif

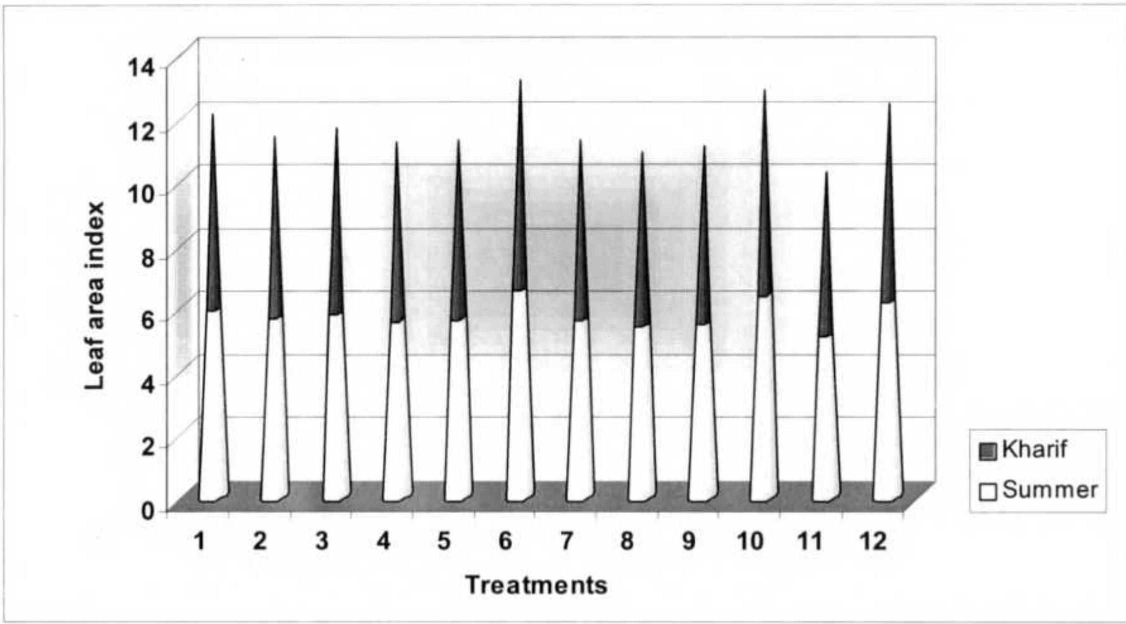

Fig.20. Mean performance of hybrids for leaf area index during summer and kharif

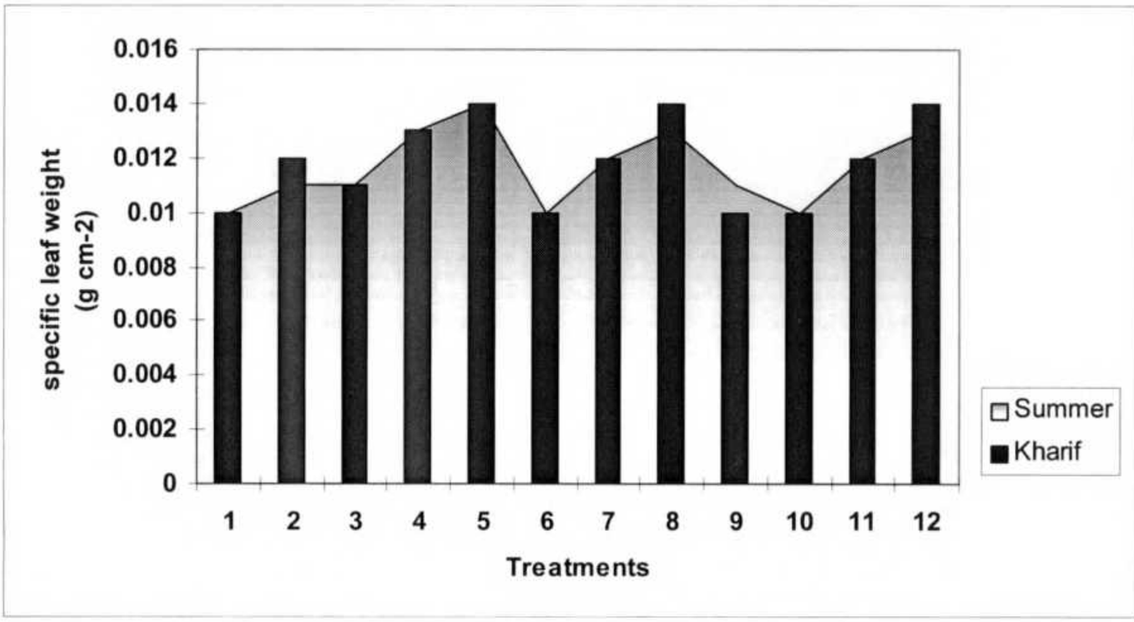

Fig.21. Mean performance of hybrids for specific leaf weight (mg cm^{-2}) during summer and kharif

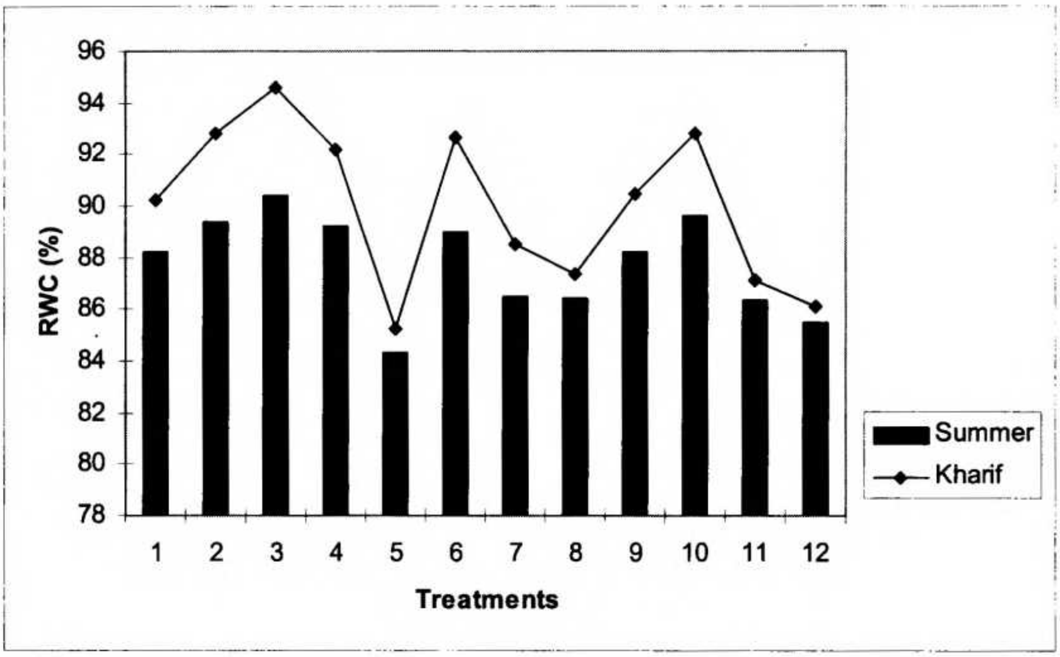

Fig.24. Mean performance of hybrids for relative water content (per cent) during summer and kharif

and this support the observations of Alberto *et al.* (1986), who found a higher crop growth rate in tomato plants having higher leaf area. The poor performing treatments in terms of yield Viz., T_5 T_7, T_8, T_{11} and T_{12} were found to have low crop growth rate compared to control (Fig.22).

The net assimilation rate follows a trend vice versa and was highest in T_{12} and lowest in T_{10} and T_6 (Fig 23). This increase in net assimilation rate of T_{12} is due to the low leaf area seen in that treatment. This gets support from the findings of Chilton *et al.* (1978), who observed a higher net assimilation rate in tomato plants with low leaf area.

Relative water content, which gives an idea of the drought tolerance of the plant, was found to be highest inT_6 and T_{10}. The treatment T_5 with irrigation regime of 40 kpa was found to poor in relative water content. Treatments T_7 with straight fertilizer fertigation, T_8 without mulching, T_{11} with topdressing of fertilizers, T_{12} with reduced spacing were also found to contain low moisture content as evidenced by relative water content values (Fig.24). This observation is further confirmed by higher water content of plants grown in kharif season than in summer. Relative water content values further exhibitted its positive association with total plant yield. This confirm the findings of Rao *et al.* (2000), who had shown a low relative water content values in tomato cultivars as a result of water stress and in turn negatively affecting the yield.

5.1.4. Nutrient content of media

The available nutrient contents of different media during kharif were higher than during summer. This effect is explained due to the loss of nutrients in summer compared to kharif and greater availability of nutrients to plants as evident by better performance. The available nitrogen content exhibited different trend compared to that of plant yield. The highest available nitrogen content was found in T_3 (when compared to control) had performed poorly in yield. This may due to the higher vegetative growth as a result of high nitrogen content (Faria *et al.,* 1999). The best performing treatments in terms of yield viz.; T_6 andT_{10} recorded average nitrogen contents, which were higher than control, whereas treatments like T_5, T_7, T_8 and T_{12} performed poor due to the stress condition suffered by the plants. So the yield performance of greenhouse tomato could be optimised by application of nitrogen basal @ 50 kg ha^{-1} + biofertilizers like azospirillum supplemented with mineral nitrogen fertigation @ 250 kg ha^{-1}. These results are in accordance with Singh *et al.* (1997) Kitamura and Nakane (1994) and Duraiswamy *et al.* (1999).

In summer and kharif, the highest available phosphorus content was recorded in soil-compost-sand in the ratio 2:1:1 (T_1) among the four different media. Among all the treatments, T_{10} recorded the highest available P content. It was found that the available P content was directly related to plant yield. Low value for available P content was recorded in treatments, T_5, T_7, T_8, T_{11} and T_{12}, which performed poorly in terms of yield. So the yield performance of greenhouse tomato could be optimised by application of phosphorus basal @ 50 kg ha^{-1} + biofertilizers like phosphobacteria supplemented with mineral phosphorus fertigation @ 250 kg ha^{-1}. These observations follow the reports of Gormley and Gen (1978), Abak *et al.* (1994), Papdopoulose (1998), Raina *et al.* (1999), Santos *et al.* (2001) and Yuan Baozhaong *et al.* (2001), who reported a positive correlation of soil P content with yield of greenhouse tomato.

In kharif and summer, available K content was directly related to fruit yield. Among the growing media, the highest available K content was found in T_1. Among all the treatments, T_6 and T_{10} recorded the highest available K content and were found to be on par with each other. Treatments T_5, T_7, T_8, T_{11} and T_{12} recorded low values for available K content and were evidenced by their poor performance of yield. Hybrid Arka Abijith found an on par available K content with hybrid SH 7611. So the yield performance of greenhouse tomato could be optimised by application of potassium basal @ 50 kg ha^{-1} + biofertilizers like azospirillum and Phosphobacteria supplemented with mineral potassium fertigation @ 250 kg ha^{-1}. These observations follow the results of Singh *et al.,* (1994), who had found a better performance of tomato with increasing levels of available nitrogen content, Santos *et al.* (2001) and Mohapatra *et al.* (1999), who had found a boosting effect of soil NPK on the yield performance of tomato.

5.1.5. Plant nutrient content

Plant nutrient contents were found to be high in kharif than in summer as evidenced by the better performance of hybrids in kharif season. The plant nitrogen content among the four growing media was recorded to be highest in T_1 and among all the treatments the highest plant nitrogen content was recorded in T_{10} followed by T_6. Even though T_{10} was found to contain higher plant nitrogen, its performance compared to T_6, in terms of yield, was poor and is explained due to the higher vegetative growth as seen in physiological observations. This confirms the report of Ikeda *et al.* (1999), who found a positive correlation of plant nitrogen content with yield of greenhouse tomato up to an optimum level beyond which it enhanced the vegetative growth and there by reducing the yield. The poor yield performers viz., T_5, T_7, T_8, T_{11} and T_{12} were found to contain low plant nitrogen content.

Plant phosphorus contents in both seasons were directly related to yield. The highest plant phosphorus content was found in T_{10} followed by T_6. The positive correlation of plant phosphorus content with yield supports the observations of Faria *et al.* (1999). The poor performers in yield viz., T_5, T_7, T_8, T_{11} and T_{12} were found to contain lower plant phosphorus content. Hybrid Arka Abijith was found to contain lower plant P compared to SH 7611.

Plant potassium contents in both seasons showed similar trend as that of the other two major nutrients. The highest plant potassium content was observed in T_6 followed by T_{10}. The poor performers in yield viz., T_5, T_7, T_8, T_{11} and T_{12} were found to contain low plant potassium. These observations are in accordance with Lin Chunhua and Huang linhua (2000) who found an increase in plant potassium content coupled with yield in greenhouse tomato, when grown with organic nutrients supplemented with inorganic fertilizers.

Thus for maximising yield by growing tomatoes in greenhouse under tropical condition, growing media of Soil: Compost: Sand in the ratio 2:1:1, irrigation regime of 20 Kpa, basal application of 50:50:50 Kg ha^{-1} NPK with straight fertilizers, fertigation @ 250: 250: 250 NPK Kg ha^{-1} with water soluble fertilizers and mulching is recommended as the suitable package of practice.

Summary

CHAPTER VI

SUMMARY

Studies were undertaken in tomato (*Lycopersicon esculentum*) with hybrids SH 7611 and the standard hybrid Arka Abjith in greenhouse for two seasons namely Summer and Kharif to assess the mean performance of the hybrids so as to develop a suitable package of practice for greenhouse tomato.

All the thirty characters studied viz., plant height, days to 50 per cent flowering, number of flowering clusters per plant, number of flowers per cluster, fruit setting percentage, number of fruiting clusters per plant, number of fruits per cluster, single fruit weight, polar diameter, equatorial diameter, yield per plant, yield per hectare, fruit firmness, total soluble solids, total sugars, titrable acidity, ascorbic acid, specific leaf area, leaf area per plant, leaf area index, specific leaf weight, crop growth rate, net assimilation rate, relative water content, available nitrogen content, available phosphorus content, available potassium content, plant nitrogen content, plant phosphorus content and plant potassium content exhibited significant differences among the treatments in two seasons.

The salient findings of the investigations are

1. All the treatments exhibited significant difference for all the traits studied.
2. Among the growing media treatments, best performance in terms of yield and quality was noticed in T_1 with soil-compost-sand in the ratio 2:1:1.
3. Among all the treatments, the best performance in terms of total fruit yield was recorded in T_6 (5.48 kg per plant) with bio-fertilizers and K

fertilizer as basal followed by T_{10} (5.30 kg per plant) with bio-fertilizers and NPK fertilizers as basal.

4. The treatments T_6 and T_{10} were found to have highest values for characters like plant height (277.15 cm and 279.52 cm), number of flower clusters per plant (59.23 and 56.13), number of flowers per cluster (10.35 and 9.95) number of fruiting clusters per plant (23.68 and 24.24), number of fruits per cluster (5.92 and 5.96), single fruit weight (81.50 g and 83.62 g), polar diameter (8.79 cm and 8.59 cm), equatorial diameter (8.27cm and 8.79 cm) yield per plant (5.48 kg and 5.30 kg) and yield per hectare (179.64 t and 173.45 t) compared to all other treatments.
5. The treatments T_6 and T_{10} were also reported to do well in terms of fruit quality and have the highest values for total sugars content (1.94 per cent and 1.92 per cent), total acidity (0.55 per cent and 0.53 per cent), and ascorbic acid (28.44 mg 100 g^{-1} and 26.91 mg 100 g^{-1}).
6. The better performance of T_6 and T_{10} could be attributed to their high record of physiological characters like specific leaf area (93.37 cm^2 g^{-1} and 92.67 cm^2 g^{-1}), leaf area per plant (1.63 cm^2 and 1.68 m^2) leaf area index (6.43 and 6.31), crop growth rate (19.34 g m^2 day^{-1} and 19.39 g $m^2 day^{-1}$) and relative water content (90.87 per cent and 91.24 per cent).
7. The better performance of T_6 and T_{10} could be attributed to their high record of available nitrogen content (191.24 kg ha^{-1} and 191.58 kg ha^{-1}), available phosphorus content (26.73 kg ha^{-1} and 26.61 kg ha^{-1}), available potassium content (664.33 kg ha^{-1} and 664.52 kg ha^{-1}), plant nitrogen content (4.02 per cent and 4.10 per cent), plant phosphorus content

(0.76 per cent and 0.80 per cent), plant potassium content (4.86 per cent and 4.84 per cent),

8. The treatment T_5 with irrigation regime of 40 kpa was observed to be performing poorly compared to control in quantitative characters as well as biochemical characters as indicated by its low record of physiological characters like specific leaf area, leaf area per plant, leaf area index, crop growth rate and relative water content, and nutrient contents in the media and plants.
9. The treatment T_7 with fertigation of straight fertilizers was reported to be performing poorly compared to control in quantitative characters as well as biochemical characters as shown in its poor record of physiological characters like specific leaf area, leaf area per plant, leaf area index, crop growth rate and relative water content, and nutrient contents in the media and plants.
10. The treatment T_8, without mulching, was also reported to be performing poorly compared to control in quantitative characters as well as biochemical characters as explained by its low record of physiological characters like specific leaf area, leaf area per plant, leaf area index, crop growth rate and relative water content, and nutrient contents in the media and plants.
11. The treatment T_{11} with topdressing of NPK fertilizers also recorded a poor account of quantitative characters as well as biochemical characters compared to control as evidenced by its poor performance in physiological characters like specific leaf area, leaf area per plant, leaf

area index, crop growth rate and relative water content, and nutrient contents in the media and plants.

12. The treatment T_{12} with reduced spacing of 30×22.5cm also was found to perform poorly as explained by the low values of physiological characters and nutrient contents in the media and plants.

13. The Hybrid SH 7611 performed better under greenhouse condition for all the character studied than the standard hybrid Arka Abijith.

14. Among the bio fertilizer treatments, T_6 was found to be doing better than T_{10} for most of the characters studied.

15. Based on these observations, T_6 with growing media of Soil: Compost: Sand in the ratio 2:1:1, irrigation regime of 20 Kpa, basal application of 50:50:50 Kg ha^{-1} NPK with straight fertilizers, fertigation @ 250: 250: 250 NPK Kg ha^{-1} with water soluble fertilizers and with mulching is recommended as the suitable package of practice for raising tomato under greenhouse condition which favoured the growth, physiological and characters that ultimately culminated in increased fruit yield with better fruit quality.

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*** Originals not seen**

Appendix

APPENDIX I

Weather data during the crop period

Month	Days	Maximum (°C)	Minimum (°C)	Relative Humidity (%)	Rainfall (mm) and Rainy days
May 2001	7-13	26.3	21.5	80	-
	14-20	25.4	20.3	77	-
	21-26	25.3	20.7	80	6.8
June 2001	23-29	25.2	20.5	74	-
	30-5	23.2	19.8	71	7.8
July 2001	6-12	23.5	20.6	81	4.3
	13-19	22.8	20.3	87	-
	20-26	21.6	19.8	88	-
	27-2	21.9	20.5	85	2.3
Aug 2001	2-8	23.2	20.8	82	-
	9-15	22.3	20.7	83	-
	16-22	22.4	21.1	84	-
	23-29	21.5	21.3	83	-
Sep 2001	30-6	21.5	20.6	81	4.3
	7-13	20.8	20.3	87	-
	14-20	21.3	19.8	88	-
	21-27	21.2	20.5	85	2.3
Oct 2001	28-4	20.2	20.8	89	40.0
	5-11	21.3	20.7	88	23.0
	12-18	21.4	21.1	89	4.5
	19-24	20.5	20.3	90	6.2
	25-31	20.6	20.6	90	-
Nov 2001	1-7	21.6	19.6	91	-
	8-14	21.2	19.7	89	4.5
	15-21	21.6	20.2	90	78.0
	22-28	21.2	20.3	92	45.0
Dec 2001	29-4	20.8	20.6	88	23.7
	5-11	20.2	19.8	87	45.0
	12-18	19.8	19.6	88	12.6
	19-25	19.6	19.5	90	-

APPENDIX I (contd..)

Jan 2002	26-4	19.8	15.8	89	-
	5-11	19.7	16.9	88	4
	12-18	18.6	17.6	92	-
	19-25	19.4	18.3	85	4.5
	26-4	19.3	17.2	79	
Feb 2002	5-11	20.7	16.3	80	-
	12-18	21.6	17.6	85	-
	19-25	21.8	20.1	81	2.3
	26-4	22.6	20.6	88	-
March 2002	5-11	23.1	19.8	84	53(1)
	12-19	23.8	20.3	83	-
	20-26	23.9	20.2	90	-
	27-2	24.2	21.3	87	-
April 2002	3-9	24.8	20.6	84	27.5(1)
	10-16	24.9	20.2	85	-
	17-23	24.6	20.4	88	2.5
	24-30	24.3	20.6	89	-
May 2002	26-4	25.6	15.8	89	-
	5-11	25.8	17.9	88	4
	12-18	26.3	17.6	92	-
	19-25	26.4	18.3	85	-
	26-4	26.9	17.2	79	-
June 2002	5-11	25.3	16.3	80	-
	12-18	25.6	17.6	85	-
	19-25	25.4	20.1	81	-
	26-4	24.8	20.6	88	-
July 2002	5-11	24.5	19.8	84	5.3
	12-19	24.2	20.3	83	-
	20-26	23.4	20.2	90	-
	27-2	22.2	21.3	87	-
Aug 2002	3-9	22.6	20.6	84	27.5(1)
	10-16	22.1	20.2	85	-
	17-23	22.6	20.4	88	2.5
	24-30	23.3	20.6	89	23.0

Plate 1. Greenhouse experiment

Plate 2. Potting plugs for tomato nursery

Plate 3. Different treatments inside the greenhouse

Plate 4. Hybrids SH 7611 and Arka Abijith

Plate 5. Best treatment T_6 with control showing number of fruits per cluster and fruit size

Plate 6. Treatment T_{10} with control showing number of fruits per cluster and fruit size

Plate 7. Treatments T_6, T_{10} and T_1 (control) showing number of fruits per cluster and fruit size

Plate 8. Crop stand in the best treatment T_6

Plate 9. Crop stand in the treatment T_{10}

Plate 10. Crop stand in control T_1