

**STUDIES ON CANOPY MANAGEMENT PRACTICES IN
HIGH DENSITY GUAVA (*Psidium guajava* L.) cv. Allahabad
Safeda**

GANGARAJA M. M.

**DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, RAICHUR
UNIVERSITY OF AGRICULTURAL SCIENCES
RAICHUR – 584 104
JULY, 2018**

**STUDIES ON CANOPY MANAGEMENT PRACTICES IN
HIGH DENSITY GUAVA (*Psidium guajava* L.) cv. Allahabad
Safeda**

*Thesis submitted to the
University of Agricultural Sciences, Raichur
In partial fulfillment of the requirement for the
Degree of*

MASTER OF SCIENCE (AGRICULTURE)

in

HORTICULTURE

By

GANGARAJA M. M.

**DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, RAICHUR
UNIVERSITY OF AGRICULTURAL SCIENCES
RAICHUR – 584 104**

JULY, 2018

UNIVERSITY OF AGRICULTURAL SCIENCES, RAICHUR
COLLEGE OF AGRICULTURE, RAICHUR
DEPARTMENT OF HORTICULTURE
RAICHUR – 584 104

CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON CANOPY MANAGEMENT PRACTICES IN HIGH DENSITY GUAVA (*Psidium guajava* L.) cv. Allahabad Safeda**” submitted by **GANGARAJA M. M.** for the award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** to the University of Agricultural Sciences, Raichur, is a record of research work carried out by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or any other similar titles.

RAICHUR

July, 2018

(A. R. KURUBAR)
CHAIRMAN

Approved by:

Chairman: _____
(A. R. KURUBAR)

Members: 1. _____
(ASHOK HUGAR)

2. _____
(SHEKHARAGOUDA PATIL)

3. _____
(R.B. NEGALUR)

ACKNOWLEDGEMENT

I humbly bow down to all the teachers right from Kindergarten whose dedicated efforts shaped my career and brought out my best in each of my endeavours.

Gratitude I feel in deep core of my heart can't be expressed explicitly in words for many people who have contributed to this effort of mine.

*I consider myself fortunate and greatly privileged to have worked under the supervision and guidance of **Dr. A. R. KURUBAR**, Professor and Head, Dept. of horticulture, AC, UAS, Raichur. I express my profound sense of gratitude and sincere thanks to him for his keen interest, invaluable focused guidance, constant encouragement, immense patience, cooperative attitude, giving respect to students, useful discussion, forbearance of my mistakes and peerless criticisms during the course of investigation and preparation of the manuscript. He has always been a fountain of inspiration to me.*

*It is great privilege for me to express my esteem and profound sense of gratitude to members of my advisory committee, **Dr. ASHOK HUGAR**, Professor, Dept. of Horticulture, AC, UAS, Raichur, **Dr. SHEKHARAGOUDA PATIL**, Asst. Professor, Department of Horticulture, AC, UAS, Raichur and **Dr. R. B. NEGALUR**, Senior Scientist and Head, ICAR-Krishi Vigyan Kendra, Vijayapura, who guided me throughout my research work. It gives tremendous pleasure to express my gratitude and indebtedness to them, for their valuable suggestions and over willing help, support and encouragement throughout this research work.*

*I want to express my gratitude to **Dr. Ramesh**, Assistant professor Department of horticulture, **Dr. Pampanna**, Head MARS, **Dr. Kaviata K.** Assistant professor of Horticulture, **Dr. Arunkumar Hosmani**, Professor of Entomology, **Dr. Meena. M. K.** Professor of Crop Physiology, **Mr. Abbas Hussain**, Associates professor of Horticulture, **Mr. M. S. Nagod**, Assistant professor of Horticulture, for extending their kind co-operation, love and motivation during the entire course of this study.*

*It is my privilege to express my gratitude to **Dr. Gutti Jambunath**, Hon'ble Vice Chancellor, UAS, Raichur, **Dr. M. G. Patil**, Dean (PGS), UAS, Raichur and **Dr. A. S. Halipyati**, Dean (Agri.), College of Agriculture, Raichur for their moral support during the course of study.*

*I also acknowledge the help of **Dr. B. S. Golasangi**, Tech. officer, Directorate of PG Studies, UAS, Raichur the meticulously editing my thesis script and also to **Veereshgouda, Mahajan Shetty, and Seenu** many more for their technical support.*

*Friends always knew how to pep me during my bad days and how to celebrate when I used to achieve something. It is difficult to express the gratitude I owe to all my friends especially **Venugopal, Anil, Prasanna, Abhishek, Ishwar, Priya, Pooja, Ashwini, Chinmayi, Pavitra**. I want to express my special thanks to **Shivu Sai Prasad, Basavaraj kods**a for their kind help and support during my research investigation.*

*I have been highly fortunate and lucky to express my heartfelt thanks to my nearest and dearest seniors and friends **Sachin, Utpal Das, Mallikarjun, Mustaq, Umesh, Sharath, Darmendra, Anuradha**. My heartily thanks to junior friends **Vishwanath, Manoj, Prashanth, Udhaykumar, Priyankamirji, Ashwini, Nethravathi, Sushma, Shwetha, Komali** and friends **Wazid, Veeresh, Adarsha, Amaresh, Ambarish, Shridar, Naveen, Manohar, Dileep, Anjaneya, Vishnu, Shivaraj, Chennu pawar** and many more for sound and fruitful advice, helping me in my research work and also a constant encouragement throughout my journey of M.Sc programme.*

*I shall never forget the enormous and timely help rendered by **Mr. Anil, Anjaneya, Raghu, Khaja, Narasappa, Mahesh**, for their kind help and support during my research..*

Words fail to express my gratitude and immense indebtedness to my respected parents for their love, affectionate care and moral support during the entire period of my study.

Innumerable numbers of persons have provided their help in course of this study. Some of them might have been missed, but none of them have been forgotten.

RAICHUR

JULY, 2018

(GANGARAJA M. M.)

AFFECTIONATELY DEDICATED

TO

MY BELOVED

PARENTS, BROTHERS, SISTER

AND

TEACHERS

CONTENTS

Chapter No.	Chapter particulars	Page No.
	CERTIFICATE	III
	ACKNOWLEDGEMENT	IV
	LIST OF ABBRVIATION	V
	LIST OF TABLES	VI
	LIST OF FIGURES	VII
	LIST OF PLATES	VIII
	LIST OF APPENDICES	IX
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-18
	2.1 High density planting	4
	2.2 Pruning	7
	2.3 Growth regulators	16
III	MATERIAL AND METHODS	19-30
	3.1 Location and climate	19
	3.2 Soil properties of experimental site	19
	3.3 Details of treatments	19
	3.4 Cultural operations	23
	3.5 Observations recorded	23
	3.6 Economics	29
	3.7 Statistical analysis and interpretation of the data	30
IV	EXPERIMENTAL RESULTS	31-58
	4.1 Growth parameters	31
	4.2 Yield and components of guava	45
	4.3 Quality parameters	50
	4.4 Economics	57

Contd....

Chapter No.	Chapter particulars	Page No.
V	DISCUSSION	60-74
	5.1 Influence of weather on crop performance	60
	5.2 Effect of canopy management on yield and yield attributes of guava	60
	5.3 Effect of canopy management on growth and growth attributes of guava	64
	5.4 Effect of canopy management on quality attributes of guava	70
	5.5 Economics	73
	5.6 Practical utility of experiment	74
	5.7 Future line of work	74
VI	SUMMARY AND CONCLUSIONS	76-77
VII	REFERENCES	78-88
VIII	APPENDICES	89

LIST OF ABBREVIATIONS

Abbreviation	Expansion
%	: Per cent
@	: At the rate of
Anon,	: Anonymous
AOAC	: Association of Official Analytical Chemists
B: C	: Benefit Cost ratio
CD	: Critical Difference
cm	: Centimetre
CO ₂	: Carbon dioxide
DAP	: Days After Pruning
EW	: East – West
<i>et al.</i>	: and others
Fig.	: Figure
FYM	: Farm Yard Manure
g	: Gram
ha	: Hectare
kg	: Kilogram
LAI	: Leaf Area Index
l	: Litre
m	: Metre
wt	: Weight
mg	: Milligram
ml	: Milli litre
mm	: Milli metre
m mol	: milli molar

Contd....

μ mol	: micro molar
NS	: North – South
N	: Newton
NS	: Non Significant
NPK	: Nitrogen, Phosphorous and Potassium
min	: Minute
$^{\circ}$ C	: Degree Celsius
PAR	: Photosynthetically Active Radiation
PN	: Net photosynthesis rate
q	: Quintals
rpm	: Rotations per minute
S.Em	: Standard error of mean
t	: Tonnes
TSS	: Total soluble solids
TV	: Titre value
<i>viz.</i>	: Namely
<i>i.e.</i>	: That is
₹	: Rupees

LIST OF TABLES

Table No.	Title	Page No.
1	Mean monthly meteorological data for the year 2017-18 at Main Agricultural Research Station, Raichur.	22
2	Plant height (m) of guava at different growth stages as influenced by canopy management practices	32
3	Plant spread (m) of guava in East-West direction at different growth stages as influenced by canopy management practices	33
4	Plant spread (m) of guava in North-South direction at different growth stages as influenced by canopy management practices	35
5	Girth of productive shoot (cm) of guava at different growth stages as influenced by canopy management practices	36
6	Length of productive shoot (cm) of guava at different growth stages as influenced by canopy management practices	37
7	Leaf area index of guava at different growth stages as influenced by canopy management practices	39
8	Light interception (%) of guava at different growth stages as influenced by canopy management practices	40
9	Canopy volume (m ³) of guava at different growth stages as influenced by canopy management practices	41
10	Chlorophyll meter readings (SPAD) of guava at different growth stages as influenced by canopy management practices	43
11	Transpiration rate (m mol H ₂ O m ⁻² s ⁻¹) of guava at different growth stages as influenced by canopy management practices	44
12	Net photosynthetic rate (μ mol CO ₂ m ⁻² s ⁻¹) of guava at different growth stages as influenced by canopy management practices	46
13	No of fruits plant ⁻¹ , fruit diameter (cm) and fruit length (cm) of guava as influenced by canopy management practices	47
14	Average fruit weight (g), fruit yield (kg plant ⁻¹) and yield (t ha ⁻¹) of guava as influenced by canopy management practices	49
15	Total soluble solids (TSS), reducing (%), non reducing (%) and Total sugars (%) of guava fruit as influenced by canopy management practices	51

Contd....

Table No.	Title	Page No.
16	Ascorbic acid (mg/100g of pulp), titrable acidity (%) and TSS: Acid ratio of guava fruit as influenced by canopy management practices	53
17	Physiological loss in weight (%) of guava fruit as influenced by canopy management practices	55
18	Shelf life (days) and organoleptic evaluation of guava fruit as influenced by canopy management practices	56
19	Economics of growing of fruits of guava as influenced by canopy management practices	58

LIST OF FIGURES

Figure No.	Title	Page No.
1	Layout plan of the experimental plot	20
2	Number of fruits plant ⁻¹ of guava as influenced by canopy management practices	61
3	Average fruit weight (g) of guava as influenced by canopy management practices	61
4	Fruit yield kg plant ⁻¹ of guava as influenced by canopy management practices	62
5	Fruit yield (t ha ⁻¹) of guava as influenced by canopy management practices	62
6	Plant height (m) of guava at different growth stages as influenced by canopy management practices	65
7	Canopy volume (m ³) of guava at different growth stages as influenced by canopy management practices	65
8	Plant spread in East-West direction (m) of guava at different growth stages as influenced by canopy management practices	66
9	Plant spread in North-South direction (m) of guava at different growth stages as influenced by canopy management practices	66
10	Length of productive shoots (cm) of guava at different growth stages as influenced by canopy management practices	67
11	Leaf area index of guava at different growth stages as influenced by canopy management practices	67
12	Light interception (%) of guava at different growth stages as influenced by canopy management practices	68
13	Chlorophyll meter readings (SPAD) of guava at different growth stages as influenced by canopy management practices	68
14	Transpiration rate (m mol H ₂ O m ⁻² s ⁻¹) of guava at different growth stages as influenced by canopy management practices	69
15	Net photosynthetic rate (μ mol CO ₂ m ⁻² s ⁻¹) of guava at different growth stages as influenced by canopy management practices	69
16	TSS ⁰ Brix of guava fruit as influenced by canopy management practices	71

Contd....

Figure No.	Title	Page No.
17	Titration acidity (%) of guava fruit as influenced by canopy management practices	71
18	Reducing (%), non reducing (%) and total sugars (%) of guava fruit as influenced by canopy management practices	72
19	Ascorbic acid (mg/100g of pulp) of guava fruit as influenced by canopy management practices	72

LIST OF PLATES

Plate No.	Title	Page No.
1	General view of experimental plot after imposing on treatment	21
2	Unproductive tertiary shoot thinning and pruning	21
3	Elite treatments under experimental plot	75
4	Fruiting potential of plant under experimental plot	59
5	Fruit length and breadth under experimental plot	59

LIST OF APPENDICES

Appendix No.	Title	Page No.
1	Prices of inputs and outputs	89

I. INTRODUCTION

Guava (*Psidium guajava* L.) is an important fruit crop grown throughout the tropical and sub-tropical areas and which belongs to the family Myrtaceae. It is a hardy, prolific bearer and highly remunerative fruit crop. The crop can be grown satisfactorily even in adverse soil and climatic conditions. It is one of the popular fruit liked by the rich and the poor alike and is popularly known as 'apple of the tropics'. It has gained considerable prominence on account of its high nutritive value, pleasant aroma, good flavour and availability at moderate price (Dinesh and Vasugi, 2010).

The major guava growing states of India are Bihar, Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Andhra Pradesh. It is one of the most important fruit crop in terms of area and production after mango, banana and citrus. The area and production of guava is increasing worldwide. In India, guava is cultivated in an area of 261.7 thousand hectares, with the production is 3648.2 thousand MT and productivity is 13.9 MT/ha. In Karnataka, the crop is cultivated in an area of 6.74 thousand hectares with a production is 130.67 MT (Anon., 2017).

The cultivars of guava commonly cultivated are botanically *Psidium guajava*. However, several *Psidium* species like *P. cattleianum*, *P. molle*, *P. acutangulam*, *P. araca*, *P. chinensis*, *P. Cujavillis* and *P. pumilum* are available at various research stations in India. About 160 guava cultivars are available in India. Guava is rich in vitamin C with fair amount of calcium, phosphorus, pantothenic acid, riboflavin, thiamin and niacin. The fruits are used for making juice, jam, jellies and various culinary products. Guava fruit also have certain antioxidant properties and is known to control systolic blood pressure. In India, guava is grown under irrigated, rain fed and dry conditions, where the rainfall ranges from 800-2000 mm. Conventional system of irrigation is normally adopted when water is not a constrain. Drip system of irrigation has become popular in Maharashtra, Tamilnadu and Karnataka for achieving optimum yield and quality of fruit in guava (Mitra *et al.*, 2008)

In tropical and subtropical conditions of northern India, two major flowering seasons are common i.e., summer (April-May) and rainy (July-August). The summer (April-May) flowering produces rainy season crop and rainy season (July-August) flowering produces winter season crop. This feature in guava cultivation is a major source of concern. Rainy season fruits are rough, insipid, poor in quality, less nutritive, easily

affected by insect pests and have very short shelf life. Due to these characteristics, guava fruits do not fetch remunerative price in the market. Whereas, the winter season fruits are superior in quality, free from diseases and pests and fetch more prices in the market. Winter season crop have better storage life and thus can be transported to far off destination offering remunerative prices.

Guava is a pruning responsive crop, shoot pruning have been reported to be successful in regulating bahar in guava. Pruning is also helpful in reducing the tree size and provides an opportunity to increase the number of trees per unit area. Untrained or un-pruned guava trees become huge and unmanageable after a couple years of growth. The bearing area is reduced and the interior of the plant becomes entirely devoid of fruiting. Trees are pruned to increase the yield and quality fruits by eliminating crowded and criss-cross branches. Pruning begins at an early stage of plant growth to develop single trunk trees with well spaced scaffold branches to form the frame work. Apical growth is to be controlled within the first year of planting for better canopy architecture (Singh, 2008).

Guava tree respond well to annual pruning and is considered suitable for high density planting. Presently, the productivity of guava is much below the productive potential, due to traditional cultural practices and prevalence of old and unproductive orchards with declining yield efficiency. Large trees take several years before they come into bearing and less number of trees per unit area is another constraint in guava production. Therefore, the main emphasis should be laid on management of tree canopy in such a way that fruits per unit area is to be increased. Generally, guava is cultivated using traditional planting system (6.0 × 6.0 m), under which it is difficult to achieve desired levels of production, because large trees provide low production per unit area and need high labour inputs. Moreover, large trees take several years before they come into bearing and overall cost of production per unit area is further increased. Hence, there is always a scope to increase production and income from a unit land area by proper management of tree canopies. There is over riding need to improve the existing planting system and to manipulate tree growth using canopy management to control tree growth patterns and tree shape and maintaining high fruit production of desired size and quality (Gorakh Singh, 2001). High density planting system and management of canopies are emphasised to achieve higher productivity per unit area.

Guava trees respond well to canopy modification with respect to vegetative and reproductive growth. Modification of canopy through pruning and use of certain growth regulators in high density could be one of the measures to enhance the production efficiency. Guava leaves exhibit response to high 'shade' and 'sun' as leaves are found to be photo synthetically inactive under deep shade and act as unproductive sink. Therefore, vegetative growth, fruit yield and quality are functions of light interception and transformation of light energy into chemical energy. Quality fruit is a function of absorption of light and light is directly proportional to the yield of fruit trees. Light interception is more in guava trees planted at wider spacing and it increases significantly with the depth of the canopies of the planting densities. Therefore, management of canopy under high density planting is a must for proper light penetration. Narrow spacing in guava increase production per unit area and fruits exhibited significantly higher values for total soluble solids, vitamin C, sugars and lower values for acidity.

For managing the canopies of the trees under high density planting approaches like pruning and use of growth retardants singly or in combinations may be exploited. But under high density planting system, light and other microclimatic conditions are important aspects which directly or indirectly affect the vegetative growth, yield and quality of guava fruits. As guava tree respond well to canopy modification with respect to vegetative and reproductive growth, modification of canopy through pruning and use of certain growth regulators in high density orchards may be the further step to enhance the production efficiency (Virendra, 2016). To assess the advantages of high density planting in guava, this study was formulated, with the following objectives.

1. To study the response of canopy management in guava under high density planting for plant growth and yield
2. To determine the impact of canopy management on quality traits of guava fruits
3. To work out the economics of guava cultivation under high density planting

II. REVIEW OF LITERATURE

Recently, there is a trend to plant fruit trees at closer spacing leading to high density orchard. The economic and higher yield in early age of the tree is of great importance in fruit production. Higher and quality production can be achieved from densely planted orchards through judicious canopy management and adoption of suitable tree training systems. In the present chapter an attempt has been made to review the literature on canopy management studies. High density planting, pruning, unproductive shoot thinning and growth retardants are factors of canopy management in guava and other crops under suitable headings.

Research work has been carried out to study the canopy management under high density planting in leading guava producing states of India as well as in other countries. A brief account of research work done in past on these aspects is reviewed and presented in this chapter under appropriate headings and sub-headings.

2.1 High density planting

2.1.1 Effect of high density planting on growth, yield and quality.

2.2 Pruning

2.2.1 Effect of pruning severity on growth and yield.

2.2.2 Effect of pruning severity on fruit quality.

2.3 Growth regulators

2.3.1 Effect of growth retardants on fruit growth, yield and quality.

2.1 High density planting

2.1.1 Effect of high density planting on growth, yield and fruit quality

Yadav (1978) studied the effect of high density planting in guava on growth, yield and fruit quality in cv. Sardar for two years. The study revealed that, the growth of the tree was decreased while tree height increased with the increased plant population. The total yield per unit area was remarkably increased with the high density population. The increase in yield was about nine times over control. The quality of fruit as revealed by TSS, sugar: acid, acidity and ascorbic acid decreased with high density planting.

Ram *et al.* (2001) conducted an experiment with different planting densities *viz.*, 5 x 5 m, 7.5 x 7.5 m, 10 x 10 m and 12.5 x 12.5 m suggested that increase in plant population is required for increasing yields in mango orchards. Annual fruit yield increased from 0.30 t/ha in fourth year to 18.0 t/ha in 14th year in high density planting of 400 trees /ha and cumulative yield was 74.12 t in 12 years of fruiting. Cumulative yield decreased to 43.29 t/ha, 25.52 t/ha and 16.91 t/ha with decrease in tree population to 177, 100 and 64 trees /ha, respectively.

Kundu (2007) studied the effect of different plant densities, *viz.*, 278 (6.0 × 6.0 m), 625 (4.0 × 4.0 m), 1111 (3.0 × 3.0 m) and 1600 (2.5 × 2.5 m) plants per hectare in guava 'L-49'. Increase in plant density markedly increased the plant height, while the basal girth of the plant and spread of the crown decreased with plant density.

Lal *et al.* (2007) studied the planting systems in guava (*Psidium guajava* L.) cv. Sardar. Double hedgerow system of planting, recorded maximum plant height (3.66 m) with higher number of plants/ha (453). Maximum values of tree spread and trunk diameter were recorded in square system of planting with lowest number of plants/ha.

Singh and Dhaliwal (2007) studied the influence of solar radiation interception on the physical characteristics of fruits of guava. 6 × 6 m spaced trees intercepted significantly higher radiation on per tree basis than 6 × 5 m and 6 × 4 m spaced trees. The size and weight of fruits harvested from the trees spaced at 6 × 6 m were found significantly higher than the trees spaced at 6 × 5 m and 6 × 4 m.

Singh *et al.* (2007) documented the effect of planting distance on growth of guava trees (*Psidium guajava* L.) cv. Allahabad Safeda. Different tree densities were studied and it was found that six years after planting tree growth significantly increased. The tree height was highest (5.76 m) at a planting distance of 3.0 × 1.5 m (2222 trees ha⁻¹). Similarly, trunk circumference was also higher (0.86 m) at 1.5 × 3.0 m when compare to the planting distance of 6.0 m × 6.0 m.

Ravishankar *et al.* (2008) studied effect of planting densities on scion girth and plant spread in guava. Stock girth and plant spread across East West direction was significantly higher in 8 x 3 or 8 x 4 m configurations.

Brar *et al.* (2012) revealed that, wider spacing of guava plant, interception of solar radiation increased significantly, plant growth in terms of tree spread (N-S) and canopy

volume increased with wide plant spacing. Wider plant spacing was found to be better, owing to maximum absorption of solar radiation and optimum microclimate in the orchard, leading to better yield in plants, higher fruiting density and yield efficiency.

Patel *et al.* (2012) studied that, effect of different planting distance on growth and yield of Aonla cv. GUJARAT AONLA- 1. Planting distance of 8.0 x 8.0 m recorded the maximum plant height (5.44 m), trunk girth (63.70 m) and tree canopy (6.18 m) during the years 2003-04, compared to other planting distance.

Sousa *et al.* (2012) reported that, effects of high density planting on 'Tommy Atkins' mango trees with planting density of 357 plants per hectare, produces 30 per cent of more yield in comparison to the control.

Dalal *et al.* (2013) assessed the effect of tree spacing on growth performance, yield parameters on kinnow mandarin. Plants were grown at three spacing 6 × 6 m, 6 × 5 m and 6 × 3 m. Maximum plant height, plant spread, canopy volume, canopy surface area, canopy foot print and trunk cross sectional area was observed under low density planting (6 × 6 m) and minimum under high density planting (6 × 3 m). Maximum crop load (276.64 fruits/plant) found in low density planting (6 × 6 m). The maximum fruit weight (171.83 g), yield (220.99 t/ha) water use efficiency (24.72 kg/ha/cm) was observed at a spacing of 6 m × 3 m.

Pal *et al.* (2015) studied the effect of different high density planting on yield and quality of guava. Significantly higher yield per plant was obtained in plant spaced at 2.0 × 1.5 m. Significantly higher yield per hectare was obtained with plant spacing of 1.0 × 1.0 m.

Gaikwad *et al.* (2017) documented that, higher yield and monetary returns was obtained by high density planting in mango variety Kesar, with spacing of 5 × 5 m with light pruning (15-20 cm terminal shoot) after harvest of fruits every year.

Mahesh *et al.* (2017) revealed that, guava plants spaced at 2.0 × 1.5 m showed that total sugars, reducing sugars, non reducing sugars, ascorbic acid and yield per plant was significantly maximum.

2.2 Pruning

2.2.1 Effect of pruning severity on growth and yield.

Kundu *et al.* (1994) conducted an experiment to know the effect of time and severity of pruning on growth, flowering, fruit setting and fruit retention on ber cv. Umran. The plants were pruned on three dates at the interval of 15 days, i.e. from 15th May to 15th June with five levels of pruning intensities. From the investigation, it was found that, the plant pruned on 30th May at 15 buds, recorded maximum fruit retention per tree.

Pawar *et al.* (1994) found that, 40 cm pruning of main stem in pomegranate was better and gave optimum number of fruits per tree (127.92), higher length of new shoot (47.82 cm) and more number of leaves per shoot (106.26). 60 cm pruning of main stem coupled with thinning, recorded higher total number of flowers per tree (381.6) and 20 cm pruning of main stems with no thinning, recorded higher shoot length and number of leaves per shoot increased with the pruning intensity.

Singh *et al.* (2001) studied the photosynthetic photon flux penetration was generally greater in canopies of pruned trees than in un-pruned trees during May and June. In all the years, the quantum of fruit yield harvestable during December and January increased significantly by May pruning.

Yeshitela *et al.* (2003) studied the effect of different kinds of pruning treatments on Keitt and Tommy Atkins cultivars over two seasons. Post harvest pruning treatments produced significantly higher results for the vegetative growth parameters in both cultivars. Pertaining to yield, the trend showed that, promising performance could be expected after the second season (with vigilant management of the trees) especially from panicle pruning at apical bud attachment and shoot pruning treatments on 'Tommy Atkins'.

Sharma and Room Singh (2006) stated that, highest number of fruited panicles appeared in moderately pruned mango trees (80.3) and the lowest in un-pruned trees (24.6). Panicles developed in higher number even at lower canopy height in severely pruned trees than un-pruned (control) as well as trees that received tipping, light or moderate pruning treatments.

Physiological and microclimate observations such as net photosynthesis, stomatal conductance were measured periodically in leaves of flowering and non flowering

branches of the rejuvenated trees. The rate of net photosynthesis was more pronounced in flowering branches of tree which was topped from 1.5 m height as compared to the non-flowering ones (Singh and Singh, 2007).

Singh *et al.* (2007) studied the topping and hedging operations in guava plants reduced tree size and consequently improved the fruiting potential of trees. As a result of topping and hedging, the tree height was reduced by 34 to 43 per cent over the control. Similarly, pruning restricted tree canopy dimension by 29.89 to 50.03 per cent over the control. The yield was not adversely affected, but fruit produced from pruned trees had better quality.

Hasan *et al.* (2009) reported the pruning at four meter height and the application of 800 g N, 300 g P₂O₅ and 1000 g K₂O along with 50 kg of FYM produced the highest shoot length, shoot girth and tree spread in both the North-South and East-West direction and produced maximum yield (40 kg/plant and 8.00 tonnes/ha) when planting density of 240 trees per hectare was maintained pruning and the nutrient levels significantly influenced the leaf area index (LAI) in the third year after pruning.

Jannoyer (2009) studied the thinning out of young flushes in mango decreased canopy density, with limited branching. These results could bring about the development of new orchard management practices leading to targetted production of good standard quality mangoes.

Shabanand Haseeb (2009) studied the effect of pruning on growth and yield of guava. Treatments i.e. pinching, moderate or severe pruning and spraying of potassium nitrate (1, 2 and 4%) after pruning were compared with the control (sprayed with water only). Significant increase in average index number of bud burst and shoot length was observed with severe pruning plus spraying of potassium nitrate at four per cent concentration compared to other treatments. A pronounced and significant increase in initial fruit set was found with moderate pruning and application of potassium nitrate at four per cent.

Gorakh Singh (2011) reported that, canopy management under high density planting in guava found highly beneficial towards better tree canopy shape and quality production. Maximum yield of 113.5 and 106.1 kg/plant was recorded as compared to 71.5 and 88.5 kg/plant under unmanaged tree canopy when planted at 3.0 x 6.0 m and 6.0 x 6.0 m spacing. Similar trend was also recorded in closer spaced trees. Among different

densities, higher yield of 80.76 per cent was obtained under the density of 3.0 x 1.5 m. Other densities 3.0 x 6.0 m, 3.0 x 3.0 m and 6.0 x 6.0 m also performed well with a increased yield of 58.74 per cent, 45.55 per cent and 19.88 per cent, respectively. Differential light interception within tree canopies as the result of pruning may influence vegetative growth, photosynthetic efficiency, flower initiation, fruit set, fruit colour, fruit size and fruit quality.

Khan *et al.* (2011) reported that, maximum numbers of leaves were recorded in the trees subjected to 100 per cent defoliation + 100 per cent deblossoming. Trees subjected to zero per cent defoliation + 50 per cent deblossoming exhibited higher fruit length, diameter and size than other treatments. In conclusion, defoliation and deblossoming had a significant impact on the vegetative and reproductive growth of guava cv. 'Gola'.

Das and Jana (2012) reported the standardize canopy architecture of rejuvenated mango plants of cv. Amrapali planted at a closer a spacing of 5.0 x 5.0 m were topped at three different heights: 1.0 m, 1.5 m and 2.0 m above ground. 1.0 m height topped plants exhibited significant differences in tree height, canopy spread and shoot girth.

Mehta *et al.* (2012) revealed that, pruning of guava plants thrice a year *viz.*, March, May and October to 50 per cent of shoot length can be recommended for maximization of income from Ultra-high density guava orchard of cv. Sardar. 50 per cent of shoot length pruning resulted in maximum yield of summer season, winter season crop and total yield per ha (34.88 t/ha and 37.24 t/ha during 2009-10 and 2010-11, respectively). With respect to gross income per ha, the maximum gross return was also obtained in case of pruning thrice a year to 50 per cent of shoot length.

Pratibha and Shantilal (2012) revealed that, one leaf pair shoot pruning significantly influenced the emergence of new shoots in guava, fruit set (%), number of fruits per tree, yield (kg/tree) and fruit quality. The maximum number of new shoots emerged (40.21) was recorded in cluster system of planting with one leaf pair shoot pruning during winter season. In one leaf pair shoot pruned trees; yield was significantly less than the un-pruned trees in rainy season whereas, yield was significantly more in one leaf pair shoot pruned trees than un-pruned trees in winter season.

Singh (2012) reported the influence of pruning intensity and pruning frequency on vegetative and reproductive attributes of guava cv. Sardar. Pruning intensities consisted of

removal of shoot tip at 0, 2nd, 4th, 6th, 8th and 10th node. The results revealed that, with the increase in severity of pruning, there was significant increase in stem girth, canopy volume and shoot length. The highest fruit yield was obtained in trees subjected to six node pruning intensity. Interaction between pruning intensity and pruning frequency showed that six node regular pruning treatment emerged as the best treatment with respect to fruit yield.

Lakpathi *et al.* (2013) found the effect of high density planting of guava cv. Allahabad Safeda with three pruning intensities i.e. leaving 10 cm, 20 cm and 30 cm from the base. 10 cm pruning intensity has recorded maximum cumulative length of new shoots (31.77 cm).

Ali *et al.* (2014) documented the effect of some pruning treatments in guava. The results obtained showed that, number of fruits per tree, yield per tree and fruit weight was better with apical 10 cm of pruning shoots at May.

Kumar *et al.* (2014) reported that, effects of tree spacing (5 x 2 m, 5 x 2.5 m, 5 x 3 m, 5 x 3.5 m and 5 x 4 m) and pruning (8 buds/cane, 6 buds/cane and 4 buds/cane) on vegetative growth, physiological parameters, fruit yield and quality were studied in fig. Best results for maintenance of vigour and fruit yield were observed under a spacing of 5 x 2 m or 5 x 2.5 m and 4 buds/cane pruning. Effects of closer spacing on growth and yield parameters were more pronounced in the 3rd year as compared to the 4th year, showing better response to treatments in young trees. Fruit yield in 3rd and 4th year of planting calculated on per hectare basis showed highest fruit number (116500-133750) and 274500-299500, and highest fruit weight of 54.5-62.0 quintals and fruit number of 158.77 -173.30, respectively, under closer spacing of 5 x 2 m and 4 buds/cane pruning.

Kumar *et al.* (2014) studied the response of pruning intensity on growth and yield of ber. Pruning intensities i.e. 10 per cent pruning on previous season growth, 20 per cent pruning on previous season growth, 30 per cent pruning on previous season growth, 40 per cent pruning on previous season growth, 50 per cent pruning on previous season growth and 60 per cent pruning on previous season growth. The growth and yield parameters *viz.*, shoot length, girth of shoots and fruit yield had been markedly promoted by the 30 per cent pruning on previous season growth.

Somkuwar *et al.* (2014) studied the effect of canopy manipulation during forward pruning of grape. Tas- A Ganesh on berry development and photosynthetic parameters.

Results indicated that, canopy manipulation practices such as shoot thinning to retain 40 shoots per vine with or without leaf removal, followed by pinching; these treatments had significant impact on photosynthesis and transpiration rates.

Gupta and Gill (2015) reported the maximum fruit weight and fruit size in terms of fruit length and fruit breadth was obtained in ber trees pruned at 8th bud level followed by the trees pruned at 10th level and minimum in the trees kept under control. The pulp percentage and pulp stone ratio was maximum in the fruit of the trees pruned at 8th bud level.

Murali *et al.* (2015) found maximum number of current season's shoot (3.25 Numbers per m²), number of panicles (16.3 Numbers per m²), percentage of bisexual flowers (31.9 %), percentage of fruit set (11.5 %) and yield (4.43 kg/ tree) in tertiary shoot pruning along with two foliar sprays *viz.*, NPK 19:19:19 at one per cent at new flush stage (August) followed by a second spray of boron 0.1 % + SOP 2 % + MAP 1 % at flowering stage (December) in cashew under high density planting system.

Tabin *et al.* (2015) studied the influence of canopy pruning on productivity of orange tree and intercrop (ginger) under rain fed conditions at Geku, Arunachal Pradesh. The rate of growth, number of fruit per tree and yield in kg per tree were significantly higher in pruned trees than control (un-pruned). The growth and yield of intercrop was also significantly higher in trees pruned at different canopy intensities. Among canopy pruning intensities, 50 percent canopy pruning intensity had higher rate of growth (5.7 %), number of fruit per tree (50) and yield in kg per tree (17.78) of orange. The rhizome yield of ginger was increased significantly at 70 per cent canopy pruning.

Meena *et al.* (2016) studied the benefits of the crop regulation in increasing the fruiting of guava cv. Lalit in off season. The selected plants were pruned in different shoot length (15, 30, 45 and 60 cm from tip) and at different months (April, May and June) having un-pruned plants as control. The shoot pruning at 45 cm in May recorded heavy fruiting (52.91 kg/plant, 14.71 t/ha) than the normal fruiting in control (22.84 kg/plant, 6.35 t/ha). Therefore, 45 cm shoot pruning in May was found to be the best for good off season production of guava.

Pal *et al.* (2016) revealed that, pruning and high density of guava with plant spacing (3.0 × 3.0 m) increased in yield significantly. Tree spread (North - South) and canopy volume increased with the plant spacing (3.0 × 3.0 m). Pruning and high density

planting was found to be better in guava owing to maximum absorption of solar radiation and optimum microclimate in the orchard leading to better yield in plants, higher fruit density and yield efficiency.

Prabhakar *et al.* (2016) studied the effect of plant spacing and pruning intensity on fruiting, flowering and yield of guava. The highest number of flower bud emergence per plant was recorded with treatment combination 2.0×2.0 m plant spacing and 3/4th shoot pruning for winter season crop. This treatment was significantly superior over other pruning treatments for emergence of new shoots. Treatment combination of 2.0×1.0 m plant spacing and three fourth shoot pruning gave maximum yield during winter season.

Saini *et al.* (2016) reported the heading back at the level of 200 cm and two pinchings were found most effective in increasing the growth characters i.e. number of sprouts per shoot, flowering intensity, fruit setting, number of fruits per plant and yield over control. Plant height, plant spread and tree volume were significantly reduced by various heading back treatments.

Thakre *et al.* (2016) reported that, among seven different forms of pruning in guava [FBT: flower bud thinning] by hand, FBTT: flower bud thinning by hand followed by removal of terminal one leaf pair, RLFO: removal of leaves and flower buds by hand, retaining one leaf pair at the top, RLF: removal of all leaves and flowers by hand, OLPS: one leaf pair shoot pruning, FSP: full shoot pruning, OLPF: one leaf pair pruning of fruited shoots only, highest yield during winter season (55.30 kg/tree) was obtained from treatment OLPF. On the basis of findings it can be concluded that, one leaf pair pruning of fruited shoots only is suitable for profitable high density management as well as crop regulation of guava in farmer friendly manner.

Deshmukh *et al.* (2017) documented the effect of thinning time and fruit spacing on yield and quality attributes. Maximum fruit weight (58.09 g), fruit length and diameter (4.79 and 4.56 cm), highest TSS (12.10°Brix); TSS: acid ratio (20.17), ascorbic acid 6.52 mg/100 g) and lowest titratable acidity (0.6 %) were recorded in fruits thinned at 20 days after full bloom and fruits thinned at spacing of 20 cm along the shoot on whole tree canopy.

Kohli *et al.* (2017) reported the effect of different pruning height 1.0 m, 1.25 m, and 1.5m from the ground level and the planting distance *viz.*, 1.0×1.0 m, 2.0×1.0 m,

2.0 × 1.5 m and 1.5 × 1.5 m on growth and yield of guava. The vegetative growth parameters in terms of tree spread (1.13 m), canopy volume (1.16 m³), tree girth (22.68 cm) were higher in the plants planted at 2.0 × 1.5 m and pruned at a height of 1.5 m. Pruning height of 1.5 m and wider spacing of 2.0 × 1.5 m may be adopted by the guava growers for getting better growth and productivity.

Nikumbhe *et al.* (2017) reported that, Sardar genotype was found significantly better for total yield per plant, marketable yield, free from fruit fly infestation were significantly higher in 15th July time of pruning and its interaction with Sardar, followed by RHR-Guava-14 genotype.

Sah *et al.* (2017) assessed the effect time of shoot pruning with different combinations on vegetative growth, flowering and yield attributes in high density planting of guava cv. Pant Prabhat. It was found that half shoot (50 %) pruning significantly influenced the vegetative growth *viz.*, plant height, plant spread, plant volume, emergence of new shoots and yield in rainy and winter season crop.

Sahoo *et al.* (2017) documented the “effect of different level of pruning on growth, yield and fruit quality of sapota cv. Cricket Ball under Coastal Zone of Odisha”. Trees were pruned in five different levels followed by sprays of five different type of hormone on 55 year old trees. Leaf chlorophyll content was recorded maximum in control (26.65 SPAD) followed by tip clipping of terminal shoots (25.82 SPAD). Both North-South (0.51 m) and East-West (0.46 m) direction. Plant spread was maximum where pruning of primary branches were done.

Photosynthetic performance and gas exchange characteristics among 22 cultivars of *Psidium guajava* were investigated under hot arid conditions of India. Net photosynthesis was maximum in Shewta (10.24 μ mol m⁻²s⁻¹) and minimum is in Arka Amulya (2.36 μ mol m⁻²s⁻¹). The transpiration rate was highest in shweta (4.25 m mol m⁻²s⁻¹) and lowest in Arka Amulya (0.06 m mol m⁻²s⁻¹). The maximum stomatal conductance was recorded in Shewta (0.24 mol m⁻²s⁻¹) and minimum in Thai guava (0.01 mol m⁻²s⁻¹). Significant differences were noticed in the rate of photosynthesis (PN), stomatal conductance (gs) and transpiration rate (E) (Shiva *et al.*, 2017).

Singh *et al.* (2017) reported that, Allahabad Safeda variety of guava received maximum PAR (1066 μE/m²/s), and also the cultivar had highest internal CO₂ concentration (Ci; 207.76 μmol/mol). Lalith genotype recorded highest net

photosynthesis rate (PN; 10.84 $\mu\text{mol CO}_2/\text{m}^2/\text{s}$), carboxylation efficiency (CE) and water use efficiency (WUE). Guava cv. L-49 recorded lowest PN (6.31 $\mu\text{mol CO}_2/\text{m}^2/\text{s}$), Ci, WUE, transpiration rate (E) and CE.

2.2.2 Effect of pruning severity on fruit quality.

Gopikrishna (1980) observed an increased in TSS & total sugar contents of guava fruits on severely pruned branches in both rainy and winter season crops, but did not report improvement in the contents of starch, titrable acidity and ascorbic acid.

Fruits from the winter season crop of guava (*Psidium guajava* L.) were stored at ambient conditions in three postures: 1) natural, pedicel and vertically upward; 2) reverse, pedicel and vertically downward; 3) horizontal, pedicel and sideways. Fruits in the natural posture showed minimum physiological loss (PLW %) in weight during storage. Organoleptic rating indicates that guava fruits should be packed in the natural posture to retain better quality for longer periods (Siddiqui *et al.*, 1991).

Shaik and Hulmani (1994) reported that, severe pruning had a beneficial effect on fruit volume and weight in case of different guava genotypes tested. TSS content increased with severe pruning but total sugars content showed no difference.

Kumar *et al.* (2003) documented the organoleptic evaluation of guava fruit (Cv. L-49). Healthy fruits recorded the highest score (4.11) for acceptance of colour. The consumers accepted the texture of fruits (4.3), taste and flavour over other. The acceptability score was 4.30 which was the highest score.

Killadi *et al.* (2007) assessed the shelf life guava cultivars i.e. Allahabad Safeda, Sardar (L-49) and Lalit. Found that, Lalit had a shelf life of nine days as it exhibited better firmness (2.1 kg/cm^2) and was enriched in vitamin C (227.33 $\text{mg}/100\text{g}$) with minimum CPLW (8.6 %). Allahabad Safeda had a short shelf life of six days only as it exhibited maximum CPLW, low firmness and high rate of respiration. Sardar guava exhibited minimum rate of respiration and ethylene production as compared to Lalit cultivar of guava.

Sathya Prakash *et al.* (2012) opined that the moderately pruned guava trees in winter season produced fruits of largest size and of maximum weight and such fruits had highest TSS and ascorbic acid content. Smallest size and minimum weight with lowest

TSS and ascorbic acid content was recorded in fruits harvested from un-pruned control trees.

Jogaiah *et al.* (2013) reported the significant variation in fruit composition parameters in response to various canopy management practices in grape. Combined treatment of leaf removal (LR) and shoot thinning (ST) exhibited high total soluble solid (TSS), lowest acidity (malic acid), lower potassium content and higher anthocyanin content. Leaf removal treatment in combination with either shoot thinning or cluster thinning was found to be superior under semi-arid tropical conditions.

Gopu *et al.* (2014) reported the effect of different pruning levels on quality characters in mango variety Alphonso. Removal of past season's growth influences the total soluble solids (18.4 %) and total sugars (13.72 %) in fruits, under ultra high density planting.

Adhikaria and Kandelb (2015) studied the effect of time and level of pruning on yield and quality of guava. Total soluble sugar (%) of fruits increased with the increased level of pruning in both rainy and winter seasons irrespective of timing of pruning, but fruit acidity was not affected by both the treatments. Pruning plants at a 20 cm pruning level in early May was the most effective management to reduce yield in the rainy season and to enhance yield and quality in the winter season.

Mehta *et al.* (2016) found that, cultivar Luvknow-49 recorded maximum fruits weight (158.08 gm), fruit length of guava (6.10 cm), diameter of guava fruit (6.45 cm), and volume of fruits (160.87 ml). Total soluble solids (11.82 °Brix), acidity (0.60 %), total soluble solids and acid ratio (44.29), total sugar content (7.38 %) and vitamin-C (ascorbic acid) in guava fruits (230.44 mg/100 gm) were found maximum in Allahabad Safeda.

Pankaj *et al.* (2016) studied shoot pruning severity in high density of guava and reported that, among the different pruning severity, thinning out of non-fruiting shoots + One leaf pair shoot pruning significantly increased the fruit yield (7.05 kg/plant), fruit quality *viz.*, TSS (13.12 °B) and ascorbic acid (242.75 mg/100 gm pulp).

Silva *et al.* (2016) revealed that 'Paluma' guava trees pruned in august showed higher phenological stage durations than the other pruning times and showed lower titratable acidity values and higher soluble solids: titratable acidity ratio.

Mahadevan *et al.* (2017) studied the “Effect of crop regulation and fertigation on quality characters of guava (*Psidium guajava*) cv. Sardar”. In this experiments three pruning levels without pruning, 15cm pruning, 30 cm pruning and five fertigations, soil application, drip fertigation of 125 per cent RDF, drip fertigation of 100 per cent RDF, drip fertigation of 75 per cent RDF, drip fertigation of 50 per cent RDF. Maximum quality attributes were recorded in the treatment where 30 per cent pruning was done and 125 per cent RDF was done in guava supplied through fertigation.

Shanmugasundaram and Balakrishnamurthy (2017) reported that, application of (GA₃ 50 ppm + KNO₃ 1 %) recorded the highest values for total sugar (9.01 %), reducing sugar (7.35 %) and total soluble solids (16.2 %) in Mridula of pomegranate under ultra high density planting.

2.3 Growth regulators

2.3.1 Effect of growth retardants on fruit growth, yield and quality

Agarwal and Dikshit (2008) studied the effect of cycocel (0, 200 and 400 ppm) sprayed at FBD stage in sapota cv. Cricket Ball. Amongst plant growth characters, the shoot length was reduced significantly by the application of CCC at 400 ppm at FBD stage. The application of CCC at 400 ppm applied at FBD stage produced significantly more number of fruits as well as yield/ tree.

Brar (2010) reported the paclobutrazol (PBZ) 500 ppm application restricted the tree volume by more than 25 per cent compared to control in guava. Paclobutrazol considerably restrict the overall vegetative growth of trees.

Brar and Bal (2010) reported influence of paclobutrazol and ethephon on reproductive growth of guava plants. Paclobutrazol (500 ppm) and ethopon (1000 ppm) were applied on plants at 6 x 2 m, 6 x 3 m, 6 x 4 m and 6 x 5 m spacing in the form of foliar application. Paclobutrazol treated plants exhibited significantly higher fruit number, fruit yield, yield efficiency and fruiting density compared to ethephon treated and control plants. With respect to flowering and fruiting, plants at wider spacing responded better to paclobutrazol applications.

Bhujbal *et al.* (2012) studied the efficiency of the growth regulators for better growth and yield of sapota variety Kalipatti. Yield per tree and yield per hectare were

significantly increases at 450 ppm CCC. Significant increases in the girth of shoots were also observed at 450 ppm CCC.

Brar *et al.* (2012) found the influence of paclobutrazol and ethephon on fruit quality of guava. Treatments in the form of foliar application were applied at 500 and 1000 ppm of paclobutrazol and ethaphon on four year old plants. Highest vitamin C (140.04 mg/100g) was recorded in fruits of 1000 ppm ethephon treated plants during rainy season. During winter season 168.2 mg/100g vitamin C was recorded in fruits of 500 ppm of ethaphon treated plants.

Lakshmi *et al.* (2014) studied the foliar spray of GA₃ 50 ppm in June followed by cycocel at 1000 ppm in September and KNO₃ one per cent in October was found to be superior with respect to number of fruits per tree (529.34), fruit weight (41.12 g) and yield (24.08 kg tree⁻¹) in acid lime. Treatment with application of GA₃ at 100 ppm in June and cycocel at 1000 ppm in September recorded highest benefit cost ratio of 2.42 followed by foliar spray of GA₃ at 50 ppm in June and cycocel 1000 ppm in September.

Gopu *et al.* (2017) studied the effect of different growth retardants on yield and yield contributing characters in mango (*Mangifera indica* L.) cv. Alphonso under ultra high density planting. The highest number of panicles per m² canopy area and number of panicles per tree were recorded in the paclobutrazol combined application of ethephon or paclobutrazol and foliar application of uniconazole (1.5 g/l). Paclobutrazol alone or with KNO₃ and uniconazole alone recorded the highest percentage of fruit set in the trees.

Hiremath *et al.* (2017) reported the influence of pruning and different plant bio regulators on physical characters of fruit, yield and cost economics of guava cv. Sardar. Fruit length (7.13 cm) and fruit weight (160.2 g) were maximum in combination of pruning and ethrel treatment. Fruit diameter (6.78 cm) was found maximum in combination of pruning and urea treatment. Higher fruit volume (165 cc) was recorded in combination of pruning and cycocel treatment.

Singh *et al.* (2017) studied the effect of different pruning intensity and plant growth regulators on Ber cv. Gola. Maximum plant height (5.55 m) and plant spread (4.60 m) was recorded 75 per cent pruning with the 10 ppm GA application. Observed highest number of sprouted shoots per branch (6.57) and shoot length (312.2 cm) have been obtained by 75 per cent pruning + 10 ppm GA application.

Rani *et al.* (2018) studied the effect of shoot pruning and paclobutrazol on growth, flowering and yield of lemon (*Citrus limon* Burm.) cv. Pant Lemon-1. The treatments consists of half shoot pruning at 45 cm intensity from the terminal portion and paclobutrazol application at 2.5 ml/tree in October to April and their combination in January, February and March. The treatment comprising half shoot pruning in October and application of paclobutrazol at 2.5 ml/tree in March were found to be more effective in terms of decrease in plant height, spread, canopy volume, cross trunk sectional area, number of new shoots, shoot length, number of male flower cluster, number of hermaphrodite flowers, number of fruits, yield kg per tree and yield distribution.

III. MATERIAL AND METHODS

An investigation on studies on canopy management practices in high density guava (*Psidium guajava* L.) was carried out at the Main Agricultural Research Station, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka during 2017-18. The details of material used and methods adopted for the investigation are outlined in this chapter.

3.1 Location and climate

Raichur is situated in North Eastern Dry Zone (Zone-II) of Karnataka 16° 15' N latitude, 77° 21' E longitude at an altitude of 389 m above mean sea level. Average rainfall of the site is 660 mm. The mean maximum temperature is more than 31.2 °C throughout the year. The relative humidity is high in monsoon months which range 55 to 70 per cent. The major rainfall is confined to late *Kharif* to early *Rabi* (August- October period). Monthly meteorological data for the year 2017-18 at the Main Agricultural Research Station, Raichur, is furnished in Table 1.

3.2 Soil properties of experimental site

The experimental site was clay loam in texture, pH 7.81 and electrical conductivity of 0.20 dS m⁻¹. The available nitrogen, phosphorous and potassium were 217.14, 31.34 and 263.20 kg ha⁻¹ respectively which indicate that the soil is medium in available P and K while deficient in available N content. However, the organic carbon content of the soil was 0.57 per cent.

3.3 Details of treatment

- T₁- No shoot thinning
- T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning
- T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning
- T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning
- T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning
- T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning
- T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning
- T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning
- T₉- Paclobutrazol 1000 ppm spray @ 75 days after first pruning
- T₁₀- Cycocel 500 ppm spray @ 75 days after first pruning

R-I	R-II	R-III	Treatment Details
T ₉	T ₁	T ₄	T ₁ - No shoot thinning
T ₇	T ₅	T ₁	T ₂ - 25 % unproductive tertiary shoot thinning @ 75 days after first pruning
T ₄	T ₂	T ₇	T ₃ - 50 % unproductive tertiary shoot thinning @ 75 days after first pruning
T ₁	T ₉	T ₅	T ₄ - 75 % unproductive tertiary shoot thinning @ 75 days after first pruning
T ₈	T ₃	T ₁₀	T ₅ - 100 % unproductive tertiary shoot thinning @ 75 days after first pruning
T ₅	T ₇	T ₃	T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning
T ₂	T ₄	T ₉	T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning
T ₆	T ₁₀	T ₂	T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning
T ₃	T ₈	T ₆	T ₉ - Paclobutrazol 1000 ppm spray @ 75 days after first pruning
T ₁₀	T ₆	T ₈	T ₁₀ - Cycocel 500 ppm spray @ 75 days after first pruning

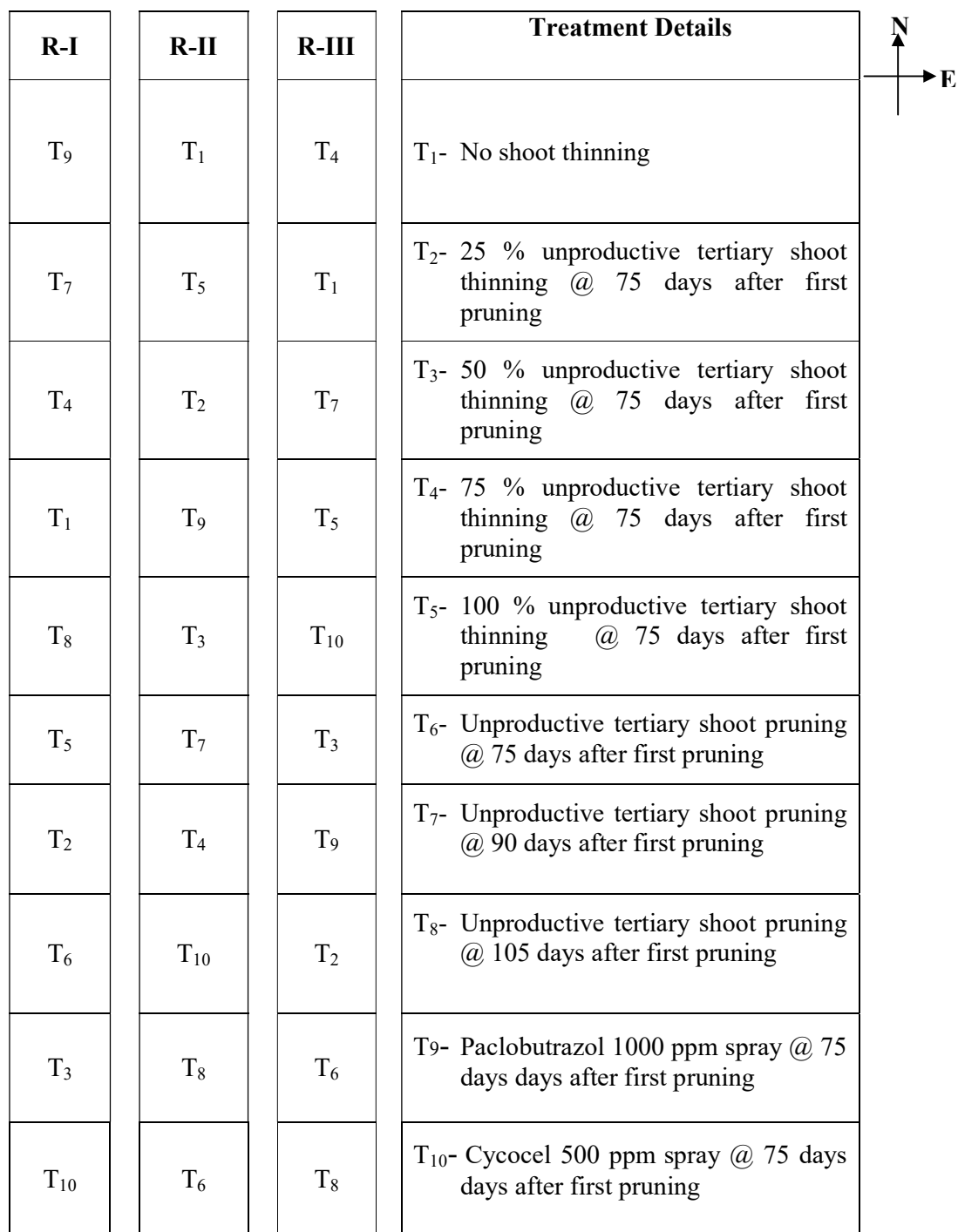


Fig. 1. Layout of plan of the experimental plot



Plate. 1: General view of experimental plot after imposing on treatment



Plate. 2: Unproductive tertiary shoot thinning and pruning

Table 1. Mean monthly meteorological data for the year 2017-18 at Main Agricultural Research Station, Raichur

Month	Rainfall (mm)		Number of rainy days		Temperature (°C)			Relative Humidity (%)	
	Normal	2017	Normal	2017	Maximum	Normal	Minimum	Normal	2017
					2017		2017		
January-17	3.9	0.0	0.0	0.0	30.6	19.8	16.2	62.3	76
February-17	0.8	0.0	0.0	0.0	33.9	21.7	19.2	59.7	61
March-17	27.3	30.0	0.0	1.0	36.9	22.6	22.6	65.2	51
April-17	50.3	7.2	0.0	1.0	40.8	23.9	26.0	61.7	53
May-17	49.7	8.1	5.0	1.0	40.3	24.7	27.7	64.6	61
June-17	61.1	159.7	7.0	8.0	34.8	24.0	24.6	70.5	82
July-17	92.1	29.7	12.0	3.0	34.3	22.7	24.1	74.7	78
August-17	172.6	197.6	4.0	14.0	32.2	22.0	22.8	76.7	87
September-17	193.2	248.4	15.0	11.0	31.1	20.7	23.3	79.8	91
October-17	72.1	193.5	2.0	8.0	30.7	20.4	22.2	74.5	92
November-17	11.9	0	0.0	0	30.9	19.0	19.4	67.9	82
December-17	4.0	0	1.0	0	29.7	18.7	16.2	67.8	85
January-18	3.9	0.0	0.0	0.0	30.5	19.8	16.5	62.3	79
February-18	0.8	0.0	0.0	0.0	32.6	21.7	22.8	59.7	68
March-18	27.3	0.0	0.0	0.0	36.8	22.6	22.4	65.2	55
Total	771	874.2	46.0	47.0					

3.4 Cultural operations

The cultural operations carried out in the experimental site are described here under the following sub heading.

3.4.1 Pruning

Five year old plants spaced at 3×3 m. Plants were pruned on 13th June, 2017 by removing the 1st order shoots to encourage the 2nd order shoots from which the crop was taken. The plant was pruned at the uniform height. Pruning was done with the help of secateurs and the cut ends were smeared with copper oxychloride. Treatments of unproductive tertiary shoot thinning, paclobutrazol and cycocel are imposed on 75 days after first pruning and unproductive tertiary shoot pruning treatments imposed on 75, 90 and 105 days after first pruning.

3.4.2 Fertilizer application

Farm yard manure and inorganic fertilizers (Urea: 300 g, DAP: 200 g, MOP: 200 g) were applied to the individual plants and foliar application of one per cent urea at two months after pruning.

3.4.3 Irrigation

The plants were irrigated through drip system regularly and quantity of discharge varied with climate conditions during the period of investigation.

3.4.4 Weeding

Hand weeding and weed cutter were carried out at monthly intervals as per requirement to avoid competition for moisture and nutrients during monsoon season in order to keep the experimental plot free from weed.

3.4.5 Fruit harvest

Harvesting of fruits was done at early ripe stage. First harvest was started on sixth October 2017 and continued up to sixth January 2018.

3.5 Observations recorded

Three plants in each treatment were tagged for recording various growth and yield characters. One kg ripe fruits were randomly selected in each treatment to study the quality and post harvest parameters.

3.5.1 Growth parameters

The growth parameters such as plant height, plant spread, girth productive tertiary shoot, length of new tertiary shoot, number of productive shoots per plant and number of unproductive shoots per plant, canopy volume, and physiological parameters such as leaf area index, light interception, SPAD readings, transpiration rate and net photosynthetic rate were recorded at 60, 90, 120, 150 and 180 days after pruning.

3.5.1.1 Plant height (m)

Plant height was measured from the base to the top of the plant and expressed in meters.

3.5.1.2 Plant spread (m)

The maximum spread of the tree was measured in North-South and East-West directions and it was averaged, separately from North-South and East-West.

3.5.1.3 Girth of new shoot (cm)

The girth of new tertiary shoot was measured in centimeter with the help of vernier caliper, five tertiary shoots were tagged at different levels of the tree canopy in all the directions of canopy and it was averaged and expressed as girth of new tertiary shoots.

3.5.1.4 Length of new tertiary shoot (cm)

For measuring the new tertiary shoot length, five newly initiated shoots on current season's growth were randomly selected at the different directions of canopy and tagged. The length of these shoots was measured with the help of measuring tape at 60, 90, 120, 150 and 180 days after pruning and pressed in centimeter.

3.5.1.5 Canopy volume (m³) by Castles formula

$$\text{Canopy volume} = \left(\frac{\text{Canopy E-W} + \text{Canopy N-S}}{2} \right)^2 \times \text{height of the plant} \times 0.8 = \text{m}^3$$

Where,

0.8 is correction factor.

3.5.1.6 Leaf area index

Leaf area index (LAI) was measured with an AccuPAR 80 ceptometer (Decagon Devices, Inc., Pullman, WA, USA) between 11:00 am to 3:00 pm. The ceptometer has 80 individual quantum sensors on the probe and automatically calculate LAI based on PRA readings from the top to ground of the canopy.

3.5.1.7 Light interception (%) in canopy

Light interception (%) was measured with an AccuPAR 80 ceptometer (Decagon Devices, Inc., Pullman, WA, USA) between 11:30 am to 3:30 pm during no cloud time. The ceptometer contains 80 individual quantum sensors on the probe and automatically calculate PAR readings. PAR readings were taken from the top and ground of the canopy by holding the probe parallel to the ground level to the sunlight. The light interception (%) was measured by using the formula.

$$\text{Light interception (\%)} = \left[1 - \frac{\text{Avg. below canopy scores}}{\text{Avg. above canopy scores}} \right] \times 100$$

3.5.1.8 Chlorophyll meter reading (SPAD meter)

The chlorophyll content of leaves was measured by using chlorophyll meter (SPAD plus 502) designed by Spectrum Technologies, Inc. The measurement was taken from four to fifth pair leaf at the middle of leaves. Several measurements were taken on each leaf and averaged to make approximate of whole and expressed as SPAD readings. The readings are between 0- 99 based on intensity of chlorophyll.

3.5.1.9 Net photosynthetic rate ($\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) and Transpiration rate ($\text{m mol H}_2\text{O m}^{-2} \text{ s}^{-1}$)

Net photosynthesis rate (PN: $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) and transpiration rate (E: $\text{m mol H}_2\text{O m}^{-2} \text{ s}^{-1}$) were measured using a portable infrared gas analyzer system (IRGA) (Li-Cor 6200, Li-Cor Biosciences, Lincoln, NE, USA). The gas exchange rates were determined at each step after maintaining the leaf for 5–10 min at the new CO_2 concentration. Five top most fully expanded leaves from each plant were selected randomly for the measurements. The leaf was enclosed in the assimilation chamber and the Pn was monitored while CO_2 concentration changed over a definite time interval. The system automatically calculated the rate of photosynthesis on the basis of preloaded flow rate and

leaf area, transpiration were also recorded simultaneously by infrared gas analyzer (Li-Cor 6200, Li-Cor Biosciences, Lincoln, NE, USA) on the same leaf. All these measurements were taken at 10:00 to 11:00 A.M (Indian standard time) when relative humidity, temperature, photosynthetic photon flux density and CO₂ concentration ranged from 50–60 per cent, 30–35 C, 1200 μ mol (photon) m⁻² s⁻¹ and 350–360 μ mol mol⁻¹, respectively.

3.5.2 Yield and yield parameters.

The yield and yield attributing characters were recorded as follows.

3.5.2.1 Number of fruits per plant

The number of the fruits per plant was recorded at each harvest and total number was calculated at last harvesting by summation of values of all pickings.

3.5.2.2 Average fruit weight (g)

The average fruit weight was calculated by weight of the fruit divided by number of fruit at each harvest and expressed in gram.

3.5.2.3 Fruit diameter (cm)

The diameter of five randomly selected fruits were measured, perpendicular to the length at the maximum width with the help of vernier calipers and average was worked out.

3.5.2.4 Fruit length (cm)

The length of five fruits of each treatment was measured from stalk to stylar end with the help of vernier calipers and after computing mean, it was recorded as average length of fruit in centimeter.

3.5.2.5 Fruit yield per plant (kg)

The weight of fruit harvested per plant at each harvesting was recorded and from that total yield per plant was worked out and expressed in kilogram.

3.5.2.6 Fruit yield (t ha⁻¹)

The yield per hectare was calculated by yield per plant multiplied by number of plants per hectare and expressed in t ha⁻¹.

3.5.3 Quality parameter

3.5.3.1 Total soluble solids (^oBrix)

Total soluble solids of fruits was determined by using digital refractrometer (ATAGO POCKET REFRACTROMETER PAL - 1) at room temperature by placing drop of guava juice on absolutely dry digital refractrometer. The ^oBrix scale expresses the concentration per cent of the soluble solids content of sample.

3.5.3.2 TSS: acid ratio

Total soluble solids per cent was divided by acidity per cent to obtain TSS: acid ratio.

3.5.3.3 Acidity (%)

Acidity was estimated by simple acid-alkali titration method as described in A.O.A.C. in (1970). 20 ml fruit juice solution was taken by pipette and transferred into a 100 ml flask and then distilled water was added to make up the volume up to 100 ml. It was shaken well to dissolve 0.25 ml of diluted fruit juice which was taken by pipette and transferred into a 250 ml beaker, and then three drops of Phenolphthaleine indicator were added in this solution. The burette was filled with N/10 NaOH solution and juice was titrated with alkali solution, drop by drop with constant stirring till the pink end point was reached. End point readings were recorded and the percentage acidity was calculated by the formula and expressed in terms of citric acid.

$$\text{Total acidity per cent} = 0.128 \times \text{titer value}$$

3.5.3.4 Reducing sugars (%)

The reducing sugars content in the fruit sample was estimated by Nelson's Somogyi method (Nelson, 1944). The preparation of working standard (10 to 100 μ g) and made up to volume to one ml with distilled water in all tubes, maintained a reagent blank with one ml distilled water and add one ml of alkaline copper reagent to all the tubes and placed in boiling water bath for 20 minutes, allowed to cool and add one ml of arsenomolybdate reagent and made up the volume to 20 ml with distilled water and read the absorbance of standard and sample against blank, which was set to 100 per cent absorbance at 540 nm in spectrophotometer.

3.5.3.5 Total sugars (%)

The total sugars content in the sample was estimated by same method as that of reducing sugars after inversion (A.O.A.C 1970). One ml of clarified extract was hydrolyzed mixture with equal volume of 1N HCL on water bath at 49 °C for 45 minutes. This hydrolyzed mixture was neutralized with 1N NaOH using methyl red as indicator and was made up to five ml. The total sugars in the hydrolyte was estimated by Nelson's Somogyi; method

3.5.3.6 Non-reducing sugar (%)

The non-reducing sugar content in the sample was worked out by deducting the value of reducing sugars from the value of total sugars in the sample.

$$\text{Non-reducing sugar (\%)} = \text{Total sugars (\%)} - \text{Reducing sugar (\%)}$$

3.5.3.7 Ascorbic acid (mg/100g of pulp)

Titrimetric method described by Ranganna (1979) was adopted for estimation of ascorbic acid.

Ten gram of fruit pulp was taken and transferred to 100 ml volumetric flask. The volume was made up with four per cent oxalic acid solution. The suspension was filtered through Whatman No.1 filter paper. Before actual titration the 2, 6-Dichlorophenol indophenol (Dye solution) was standardized by titrating against standard ascorbic acid solution and dye factor was calculated. Five ml of the aliquot was taken from the filtrate and titrate against standardized dye solution through a burette. The titration was continued till the light pink colour persisted for 15 seconds. The ascorbic acid was calculated using the following formula and expressed as mg ascorbic acid per 100 g fresh weight.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Vol. made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{weight of sample taken for estimation}} \times 100$$

3.5.4 Shelf life parameters

A sample of one kg were collected from each treatment and brought to laboratory and stored at room temperature. The shelf life parameters were determined as described below.

3.5.4.1 Shelf life (days)

The number of days taken from harvest to marketable stage was counted by keeping the fruits at ambient temperature

3.5.4.2 Physiological Loss in Weight (%)

Observation was recorded every day in respect of the physiological loss in weight of fruits. The weights of the fruits were measured by using a weighing balance of ± 0.001 g accuracy. Physiological loss in weight was expressed as per cent loss in weight using the formula given below (Kurubar, 2007).

$$\text{PLW (\%)} = \frac{\text{Initial fruit weight (g)} - \text{weight of fruits on the date of observation (g)}}{\text{Initial weight of fruit}} \times 100$$

3.5.4.3 Organoleptic evaluation

Organoleptic evaluation of guava fruit was done by a panel of five members. The observation was recorded based on hedonic scale. Parameters like colour, firmness, taste, aroma and overall acceptability were evaluated by nine point scale (1- like extremely, 2- like very much, 3- like moderately, 4- like slightly, 5- neither like nor dislike, 6- dislike slightly, 7- dislike moderately, 8- dislike very much and 9- dislike extremely) .

3.6. Economics

The cost of the following items was considered for working out of cultivation of guava.

1. Fertilizers
2. Growth retardant chemicals
3. Labour charges
4. Plant protection chemicals
5. Miscellaneous (marketing charges)

The price of inputs that were prevailing at the time of investigation was taken into account to work out the cost of cultivation. Gross returns were calculated using the fruit yield and the price of fruits at the time of marketing was considered. The labour wages cost of inputs and outputs are furnished in appendix I.

A net return per hectare was calculated by deducting cost of cultivation per hectare from gross returns per hectare. The benefit cost ratio was worked out as follows

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.7 Statistical analysis and interpretation of the data

The data collected on different parameters during the course of investigation were subjected to Fisher's method of analysis of variance and interpretation of data was done as per the procedure described by Panse and Sukhatme (1985). The level of significance used in 'F' and 't' test was P= 0.05. Values obtained in percentage were subjected to angular transformation.

IV. EXPERIMENTAL RESULTS

The present investigation entitled, “Studies on canopy management practices in high density guava (*Psidium guajava* L.) cv. Allahabad Safeda” was carried out at Horticulture farm, Main Agricultural Research Station, UAS, Raichur Karnataka. The observations recorded on various parameters during the course of investigation were statistically analysed and the results obtained are presented under an appropriate headings and sub headings.

4.1 Growth parameters

4.1.1 Plant height (m)

The data pertaining to the plant height of guava at different growth stages as influenced by canopy management practices is presented in Table 2.

There was no significant difference in plant height at 60 and 90 days after pruning. However, significant differences among the treatments were observed at 120, 150 and 180 days. The plant height was found highest (2.60, 2.95 and 3.15 m) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning, which was recorded at 120, 150 and 180 days, respectively and also on par with 75 per cent unproductive tertiary shoot thinning (2.57, 2.90 and 3.04 m), 50 per cent unproductive tertiary shoot thinning (2.55, 2.85 and 3.01 m) and 25 per cent unproductive tertiary shoot thinning (2.52, 2.84 and 2.99 m) at 75 days after first pruning, respectively. While, a least plant height was recorded in no shoot thinning (2.29, 2.55 and 2.72 m).

4.1.2 Plant spread (m) of guava in E-W

Plant spread of guava in east- west did not differed significantly at 60 and 90 days after pruning. But, among the treatments significant differences were noticed at 120, 150 and 180 days. The plant spread of guava in east-west was recorded highest (3.77, 3.97 and 4.15 m) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively (Table 3), which was also on par with 75 per cent unproductive tertiary shoot thinning (3.74, 3.94 and 4.09 m), 50 per cent unproductive tertiary shoot thinning (3.71, 3.91 and 3.94 m) and 25 per cent unproductive tertiary shoot thinning (3.68, 3.89 and 3.92 m) at 75 days after first pruning, respectively and no shoot thinning (3.26, 3.45 and 3.62 m) was recorded the least plant spread.

Table 2. Plant height (m) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	1.68	1.85	2.29	2.55	2.72
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	1.75	1.94	2.52	2.84	2.99
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	1.79	1.96	2.55	2.85	3.01
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	1.82	1.99	2.57	2.90	3.04
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	1.87	2.08	2.60	2.95	3.15
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	1.73	1.93	2.44	2.74	2.93
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	1.72	1.92	2.40	2.72	2.91
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	1.71	1.90	2.34	2.61	2.80
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	1.69	1.88	2.31	2.58	2.75
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	1.70	1.89	2.33	2.60	2.76
S.Em. ±	0.08	0.05	0.05	0.06	0.06
C.D. (p=0.05)	NS	NS	0.15	0.19	0.19

DAP- Days after pruning

Table 3. Plant spread (m) of guava in East-West direction at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	2.98	3.08	3.26	3.45	3.62
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.13	3.29	3.68	3.89	3.92
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.16	3.33	3.71	3.91	3.94
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.18	3.36	3.74	3.94	4.09
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.21	3.38	3.77	3.97	4.15
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	3.12	3.27	3.38	3.63	3.85
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	3.11	3.25	3.37	3.62	3.82
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	3.09	3.24	3.35	3.61	3.76
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	3.02	3.17	3.32	3.58	3.68
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	3.07	3.22	3.34	3.60	3.72
S.Em. ±	0.12	0.09	0.12	0.10	0.08
C.D. (p=0.05)	NS	NS	0.35	0.31	0.23

DAP- Days after pruning

4.1.3 Plant spread (m) of guava in N-S

There was a significant difference was observed at 120, 150 and 180 days. The maximum plant spread of guava in north south was recorded (3.82, 3.97 and 4.19 m) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning, which was recorded at 120, 150 and 180 days after pruning, respectively and it was also on par with 75 per cent unproductive tertiary shoot thinning (3.80, 3.95 and 4.15 m), 50 per cent unproductive tertiary shoot thinning (3.79, 3.92 and 4.12 m) and 25 per cent unproductive tertiary shoot thinning (3.77, 3.89 and 4.09 m) at 75 days after first pruning, respectively. Further, a minimum plant spread was noticed in no shoot thinning (3.49, 3.69 and 3.76 m) (Table 4) and no significant difference was observed in plant spread at 60 and 90 days after pruning.

4.1.4 Girth of productive shoot (cm)

Significant differences among the treatments were observed at 120, 150 and 180 days after pruning. The highest girth of productive shoot was recorded (1.15, 1.46 and 1.64 cm) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning, which was recorded at 120, 150 and 180 days after pruning, respectively (Table 5). It was also on par with 75 per cent unproductive tertiary shoot thinning (1.10, 1.43 and 1.61 cm), 50 per cent unproductive tertiary shoot thinning (1.08, 1.41 and 1.60 cm) and 25 per cent unproductive tertiary shoot thinning (1.05, 1.37 and 1.57 cm) at 75 days after first pruning, respectively and a least girth of productive shoot was recorded in no shoot thinning (0.92, 1.04 and 1.20 cm). However, there was no significant difference was observed in girth of productive shoot at 60 and 90 days after pruning.

4.1.5 Length of productive shoot (cm)

The data pertaining to the length of productive shoot of guava at different growth stages as influenced by canopy management practices is presented (Table 6).

There was no significant difference in length of productive shoot at 60 and 90 days after pruning. However, significant differences among the treatments were observed at 120, 150 and 180 days. The length of productive shoot was found to be highest (93.33, 109.39 and 126.31 cm) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively, which was also on par with 75 per cent unproductive tertiary shoot thinning

Table 4. Plant spread (m) of guava in North-South direction at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	3.19	3.39	3.49	3.69	3.76
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.29	3.48	3.77	3.89	4.09
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.30	3.52	3.79	3.92	4.12
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.31	3.54	3.80	3.95	4.15
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.33	3.55	3.82	3.97	4.19
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	3.28	3.47	3.58	3.80	3.96
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	3.27	3.46	3.57	3.79	3.94
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	3.26	3.45	3.55	3.75	3.86
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	3.22	3.42	3.51	3.71	3.82
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	3.25	3.44	3.52	3.73	3.84
S.Em.±	0.05	0.07	0.08	0.05	0.06
C.D. (p=0.05)	NS	NS	0.23	0.15	0.19

DAP- Days after pruning

Table 5. Girth of productive shoot (cm) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	0.61	0.75	0.92	1.04	1.20
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	0.71	0.84	1.05	1.37	1.57
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	0.72	0.85	1.08	1.41	1.60
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	0.74	0.86	1.10	1.43	1.61
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	0.76	0.88	1.15	1.46	1.64
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	0.70	0.82	0.99	1.13	1.33
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	0.68	0.81	0.98	1.11	1.29
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	0.67	0.79	0.97	1.10	1.28
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	0.64	0.76	0.94	1.06	1.24
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	0.65	0.77	0.96	1.09	1.28
S.Em. ±	0.06	0.03	0.05	0.10	0.09
C.D. (p=0.05)	NS	NS	0.14	0.28	0.26

DAP- Days after pruning

Table 6. Length of productive shoot (cm) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	49.67	54.00	72.67	87.35	103.03
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	53.43	61.33	84.67	102.15	118.20
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	54.33	62.67	88.00	104.29	121.35
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	55.67	65.67	89.67	107.85	123.66
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	57.27	68.33	93.33	109.39	126.31
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	52.51	60.67	80.33	94.37	111.03
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	51.67	59.33	80.00	93.64	110.02
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	51.33	57.33	79.33	92.63	109.65
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	50.33	56.00	76.00	90.58	105.36
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	50.67	57.00	78.67	91.23	106.68
S.Em. ±	2.79	3.48	3.75	4.69	4.37
C.D. (p=0.05)	NS	NS	11.13	13.94	12.98

DAP- Days after pruning

(89.67, 107.85 and 123.66 cm), 50 per cent unproductive tertiary shoot thinning (88.00, 104.29 and 121.35 cm) and 25 per cent unproductive tertiary shoot thinning (84.67, 102.15 and 118.20 cm) at 75 days after first pruning, respectively and lowest length of productive shoot was recorded in no shoot thinning (72.67, 87.35 and 103.03 cm).

4.1.6 Leaf area index

Significant difference was not observed in leaf area index at 60 and 90 days after pruning. However, among the treatments significant differences were observed at 120, 150 and 180 days. The leaf area index was found to be highest (4.87, 4.58 and 4.25) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively (Table 7), which was also on par with 75 per cent unproductive tertiary shoot thinning (4.76, 4.49 and 4.14), 50 per cent unproductive tertiary shoot thinning (4.64, 4.38 and 4.09) and 25 per cent unproductive tertiary shoot thinning (4.57, 4.31 and 4.03) at 75 days after first pruning, respectively and no shoot thinning (3.84, 3.65 and 3.40) was recorded least in leaf area index.

4.1.7 Light interception (%)

The data pertaining to the light interception at different growth stages as influenced by canopy management practices is presented (Table 8).

Light interception at 60 and 90 days after pruning was not differed significantly. However, at 120, 150 and 180 days were noticed significant difference among the treatments. The light interception was recorded highest (81.48, 80.98 and 82.01%) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively, which was also on par with 75 per cent unproductive tertiary shoot thinning (79.94, 78.31 and 80.27 %), 50 per cent unproductive tertiary shoot thinning (78.68, 77.69 and 79.65 %) and 25 per cent unproductive tertiary shoot thinning (77.30, 76.31 and 78.63 %) at 75 days after first pruning, respectively and the lowest light interception was recorded in no shoot thinning (67.91, 69.28 and 73.02 %).

4.1.8 Canopy volume (m³)

A significant difference among the treatments was observed at 90, 120, 150 and 180 days after pruning. The canopy volume was found to be highest (19.92, 29.96, 37.19

Table 7. Leaf area index of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	3.36	3.81	3.84	3.65	3.40
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.57	4.05	4.57	4.31	4.03
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.61	4.09	4.64	4.38	4.09
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.63	4.12	4.76	4.49	4.14
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.66	4.15	4.87	4.58	4.25
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	3.55	3.98	4.21	4.19	3.89
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	3.52	3.96	4.19	4.12	3.73
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	3.48	3.92	4.09	4.03	3.67
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	3.42	3.85	3.92	3.78	3.49
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	3.46	3.88	3.99	3.98	3.54
S.Em. ±	0.16	0.09	0.18	0.11	0.09
C.D. (p=0.05)	NS	NS	0.53	0.34	0.25

DAP- Days after pruning

Table 8. Light interception (%) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	66.59	68.62	67.91	69.28	73.02
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	71.77	73.67	77.30	76.31	78.63
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	72.19	74.34	78.68	77.69	79.65
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	72.58	75.61	79.94	78.31	80.27
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	73.89	77.42	81.48	80.98	82.01
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	69.33	72.35	73.16	73.68	75.96
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	69.17	71.92	72.32	73.35	75.74
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	68.52	71.28	71.65	72.73	75.40
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	67.84	69.59	67.96	70.63	73.34
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	68.07	70.30	69.60	71.94	74.31
S.Em. ±	2.87	2.76	2.57	2.27	1.90
C.D. (p=0.05)	NS	NS	7.64	6.73	5.64

DAP- Days after pruning

Table 9. Canopy volume (m³) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	12.76	15.41	20.87	26.07	29.95
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	14.45	18.34	28.03	34.32	40.89
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	14.98	18.43	28.56	35.00	41.02
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	15.34	18.98	29.31	36.09	42.42
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	15.98	19.92	29.96	37.19	43.80
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	14.27	17.61	23.64	30.37	35.78
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	13.98	17.29	23.16	29.78	35.12
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	13.84	17.05	22.33	28.30	32.49
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	13.18	16.35	21.49	27.42	30.92
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	13.60	16.77	22.00	27.97	31.55
S.Em. ±	0.91	0.57	1.02	1.28	1.05
C.D. (p=0.05)	NS	1.69	3.04	3.79	3.13

DAP- Days after pruning

and 43.80 m³) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively (Table 9), and it was also on par with 75 per cent unproductive tertiary shoot thinning (18.98, 29.31, 36.09 and 42.42 m³), 50 per cent unproductive tertiary shoot thinning (18.43, 28.56, 35.00 and 41.02 m³) and 25 per cent unproductive tertiary shoot thinning (18.34, 28.03, 34.32 and 40.89 m³) at 75 days after first pruning, respectively and a least canopy volume was recorded in no shoot thinning (15.41, 20.87, 26.07 and 29.95 m³). However, there was no significant difference in canopy volume at 60 days after pruning.

4.1.9 SPAD readings

SPAD readings at 60 days after pruning were not differed significantly. However, significant differences among the treatments were observed at 90, 120, 150 and 180 days. The SPAD readings was recorded highest (49.35, 48.45, 43.95 and 41.92) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 90, 120, 150 and 180 days after pruning, respectively (Table 10), which was also on par with 75 per cent unproductive tertiary shoot thinning (47.48, 45.17, 42.03 and 39.73), 50 per cent unproductive tertiary shoot thinning (46.32, 43.60, 41.96 and 38.68) and 25 per cent unproductive tertiary shoot thinning (45.12, 42.67, 41.18 and 37.99) at 75 days after first pruning, respectively and a least SPAD readings was recorded in no shoot thinning (34.40, 32.60, 31.17 and 30.52).

4.1.10 Transpiration rate (m mol H₂O m⁻² s⁻¹)

The data pertaining to the transpiration rate at different growth stages as influenced by canopy management practices is presented (Table 11).

Transpiration rate at 60 and 90 days after pruning did not differed significantly. However, significant differences among the treatments were observed at 120, 150 and 180 days. The transpiration rate was recorded maximum (5.22, 4.93 and 4.82 m mol H₂O m⁻² s⁻¹) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively, which was also on par with 75 per cent unproductive tertiary shoot thinning (5.01, 4.83 and 4.40 m mol H₂O m⁻² s⁻¹), 50 per cent unproductive tertiary shoot thinning (4.86, 4.45 and 4.33 m mol H₂O m⁻² s⁻¹) and 25 per cent unproductive tertiary shoot thinning (4.54, 4.36 and 4.31 m mol H₂O m⁻² s⁻¹) at 75 days after first pruning, respectively and a minimum transpiration rate was recorded in no shoot thinning (3.51, 3.36 and 3.13 m mol H₂O m⁻² s⁻¹).

Table 10. Chlorophyll meter readings (SPAD) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	33.67	34.40	32.60	31.17	30.52
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	41.88	45.12	42.67	41.18	37.99
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	42.40	46.32	43.60	41.96	38.68
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	43.66	47.48	45.17	42.03	39.73
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	44.40	49.35	48.45	43.95	41.92
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	38.95	39.73	38.65	34.92	33.76
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	37.35	38.70	37.65	34.86	32.93
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	36.11	36.79	35.93	34.23	32.36
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	34.95	35.63	34.62	32.68	31.07
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	35.67	36.43	35.68	33.97	31.78
S.Em. ±	3.16	3.18	3.06	2.75	1.61
C.D. (p=0.05)	NS	9.46	9.09	8.16	4.80

DAP- Days after pruning

Table 11. Transpiration rate (m mol H₂O m⁻² s⁻¹) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	3.31	3.83	3.51	3.36	3.13
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	3.93	4.32	4.54	4.36	4.31
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	4.14	4.51	4.86	4.45	4.33
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	4.23	4.92	5.01	4.83	4.40
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	4.26	4.95	5.22	4.93	4.82
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	3.81	4.11	4.35	4.16	3.97
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	3.74	3.96	4.21	4.02	3.75
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	3.71	3.91	4.01	3.87	3.66
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	3.51	3.84	3.82	3.57	3.45
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	3.63	3.86	3.93	3.75	3.59
S.Em. ±	0.20	0.29	0.24	0.22	0.17
C.D. (p=0.05)	NS	NS	0.70	0.65	0.51

DAP- Days after pruning

4.1.11 Net photosynthetic rate ($\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)

There was no significant difference in net photosynthetic rate at 60 and 90 days after pruning. However, significant differences among the treatments were observed at 120, 150 and 180 days. The net photosynthetic rate was found to be maximum (12.12, 11.31 and 10.71 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was recorded at 120, 150 and 180 days after pruning, respectively (Table 12), and it was also on par with 75 per cent unproductive tertiary shoot thinning (11.19, 10.85 and 10.26 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), 50 per cent unproductive tertiary shoot thinning (11.07, 10.07 and 9.96 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) and 25 per cent unproductive tertiary shoot thinning (10.51, 9.86 and 9.82 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) at 75 days after first pruning, respectively and a minimum net photosynthetic rate was recorded in no shoot thinning (8.50, 7.49 and 7.18 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$).

4.2 Yield and yield components of guava

Yield and yield components of guava recorded at different stages of harvesting are presented in Table 13 and 14.

All the yield components and fruits morphological features were significantly influenced by canopy management practices.

4.2.1 No of fruits per plant

There was a significant difference was noticed in number of fruits per plant. Maximum number of fruits per plant was recorded in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (267.07) (Table 13), which was also on par with 75 per cent unproductive tertiary shoot thinning (250.52), 50 per cent unproductive tertiary shoot thinning (246.29) and 25 per cent unproductive tertiary shoot thinning (241.37) at 75 days after first pruning and no shoot thinning (198.84) was recorded minimum number of fruits per plant.

4.2.2 Fruit diameter (cm)

Fruit diameter was found to be significantly highest with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (6.30 cm) (Table 13), which was also on par with 75 per cent unproductive tertiary shoot thinning (6.23 cm), 50

Table 12. Net photosynthetic rate ($\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) of guava at different growth stages as influenced by canopy management practices

Treatments	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T ₁ - No shoot thinning	7.38	8.02	8.50	7.49	7.18
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	8.94	9.59	10.51	9.86	9.82
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	9.36	9.77	11.07	10.07	9.96
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	9.53	9.91	11.19	10.85	10.26
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	9.85	10.64	12.12	11.31	10.71
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	8.72	9.19	10.12	9.01	8.71
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	8.52	8.99	9.83	8.77	8.33
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	8.22	8.76	9.36	8.45	8.16
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	7.53	8.28	8.75	7.83	7.46
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	7.93	8.52	9.03	8.29	7.93
S.Em. \pm	0.78	0.66	0.57	0.52	0.32
C.D. (p=0.05)	NS	NS	1.70	1.55	0.96

DAP- Days after pruning

Table 13. No of fruits plant⁻¹, fruit diameter (cm) and fruit length (cm) of guava as influenced by canopy management practices

Treatments	No of fruits plant ⁻¹	Fruit diameter (cm)	Fruit length (cm)
T ₁ - No shoot thinning	198.84	5.12	5.34
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	241.37	5.94	6.57
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	246.29	6.18	6.76
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	250.52	6.23	7.02
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	267.07	6.30	7.15
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	211.91	5.47	6.32
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	211.66	5.41	6.16
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	209.44	5.36	5.99
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	208.61	5.23	5.64
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	209.23	5.33	5.78
S.Em. ±	13.28	0.27	0.27
C.D. (p=0.05)	39.47	0.80	0.82

per cent unproductive tertiary shoot thinning (6.18 cm) and 25 per cent unproductive tertiary shoot thinning (5.94 cm) at 75 days after first pruning. A least fruit diameter was recorded in no shoot thinning (5.12 cm).

4.2.3 Fruit length (cm)

Fruit length significantly influenced by canopy management practices is presented in Table 13.

Among the treatments, 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning was recorded maximum fruit length (7.15 cm), which was also on par with 75 per cent unproductive tertiary shoot thinning (7.02 cm), 50 per cent unproductive tertiary shoot thinning (6.76 cm) and 25 per cent unproductive tertiary shoot thinning (6.57 cm) at 75 days after first pruning and minimum (5.34 cm) fruit length was recorded in no shoot thinning.

4.2.4 Average fruit weight (g)

A significantly maximum average fruit weight was recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (161.23 g) (Table 14), which was also on par with 75 per cent unproductive tertiary shoot thinning (158.35 g), 50 per cent unproductive tertiary shoot thinning (157.36 g) and 25 per cent unproductive tertiary shoot thinning (155.39 g) at 75 days after first pruning and a minimum average fruit weight was recorded in no shoot thinning (122.63 g).

4.2.5 Fruit yield per plant (kg)

A significantly highest fruit yield per plant was recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (42.98 kg) (Table 14). which was also on par with 75 per cent unproductive tertiary shoot thinning (39.64), 50 per cent unproductive tertiary shoot thinning (38.74 kg) and 25 per cent unproductive tertiary shoot thinning (37.48 kg) at 75 days after first pruning and a lowest fruit yield per plant was recorded in no shoot thinning (24.42 kg).

4.2.6 Fruit yield ($t\ ha^{-1}$)

The data presented in Table 14 revealed that, significantly highest fruit yield per hectare was recorded with 100 per cent unproductive tertiary shoot thinning at 75 days

Table 14. Average fruit weight (g), fruit yield (kg plant⁻¹) and yield (t ha⁻¹) of guava as influenced by canopy management practices

Treatments	Average fruit weight (g)	Fruit yield (kg plant⁻¹)	Yield (t ha⁻¹)
T ₁ - No shoot thinning	122.63	24.42	27.13
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	155.39	37.48	41.64
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	157.36	38.74	43.03
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	158.35	39.64	44.04
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	161.23	42.98	47.75
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	145.60	30.86	34.28
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	138.17	29.13	32.37
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	134.40	28.29	31.43
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	129.56	27.03	30.03
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	132.29	27.67	30.74
S.Em. ±	4.29	2.14	2.38
C.D. (p=0.05)	12.76	6.36	7.06

after first pruning (47.75 t ha^{-1}), which was also on par with 75 per cent unproductive tertiary shoot thinning (44.04 t ha^{-1}), 50 per cent unproductive tertiary shoot thinning (43.03 t ha^{-1}) and 25 per cent unproductive tertiary shoot thinning (41.64 t ha^{-1}) at 75 days after first pruning and a lowest fruit yield per hectare was recorded in no shoot thinning (27.13 t ha^{-1}).

4.3 Quality parameters

4.3.1 Total soluble solids ($^{\circ}\text{Brix}$)

Total soluble solids significantly influenced by canopy management practices are presented (Table 15).

Significantly highest total soluble solids were recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning ($11.21 \text{ }^{\circ}\text{Brix}$), which was also on par with 75 per cent unproductive tertiary shoot thinning ($10.97 \text{ }^{\circ}\text{Brix}$), 50 per cent unproductive tertiary shoot thinning ($10.88 \text{ }^{\circ}\text{Brix}$) and 25 per cent unproductive tertiary shoot thinning ($10.81 \text{ }^{\circ}\text{Brix}$) at 75 days after first pruning while, least total soluble solids was recorded in no shoot thinning ($8.95 \text{ }^{\circ}\text{Brix}$).

4.3.2 Reducing sugars (%)

Among the treatments significantly maximum reducing sugars were found to be in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (5.40 %) (Table 15), which was found to be on par with 75 per cent unproductive tertiary shoot thinning (5.14 %), 50 per cent unproductive tertiary shoot thinning (4.88 %) and 25 per cent unproductive tertiary shoot thinning (4.59 %) at 75 days after first pruning and a minimum reducing sugars were observed in no shoot thinning (3.75 %).

4.3.3 Non reducing sugars (%)

The data presented in Table 15 revealed that, significantly higher non reducing sugars were observed in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (5.04 %), which was found to be on par with 75 per cent unproductive tertiary shoot thinning (4.89 %), 50 per cent unproductive tertiary shoot thinning (4.76 %) and 25 per cent unproductive tertiary shoot thinning (4.39 %) at 75 days after first pruning and a minimum non reducing sugars were recorded in no shoot thinning (3.23 %).

Table 15. Total soluble solids (TSS), reducing (%), non reducing (%) and total sugars (%) of guava fruit as influenced by canopy management practices

Treatments	TSS (^oBrix)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
T ₁ - No shoot thinning	8.95	3.75	3.23	6.98
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	10.81	4.59	4.39	8.97
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	10.88	4.88	4.76	9.65
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	10.97	5.14	4.89	10.02
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	11.21	5.40	5.04	10.43
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	9.63	4.04	3.88	7.92
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	9.50	3.97	3.64	7.60
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	9.31	3.91	3.51	7.43
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	9.10	3.82	3.36	7.17
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	9.15	3.85	3.47	7.32
S.Em. ±	0.17	0.33	0.26	0.56
C.D. (p=0.05)	0.51	0.99	0.77	1.65

4.3.4 Total sugars (%)

Among the treatments significantly highest total sugars were recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (10.43 %) (Table 15), which was also on par with 75 per cent unproductive tertiary shoot thinning (10.02 %), 50 per cent unproductive tertiary shoot thinning (9.65 %) and 25 per cent unproductive tertiary shoot thinning (8.97 %) at 75 days after first pruning and no shoot thinning (6.98 %) were recorded a least total sugars.

4.3.5 Ascorbic acid (mg/100 g of pulp)

Ascorbic acid significantly influenced by canopy management practices is presented (Table 16).

Ascorbic acid was recorded maximum with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (227.38 mg/100 g of pulp), which was also on par with 75 per cent unproductive tertiary shoot thinning (218.88 mg/100 g of pulp), 50 per cent unproductive tertiary shoot thinning (209.26 mg/100 g of pulp) and 25 per cent unproductive tertiary shoot thinning (201.57 mg/100 g of pulp) at 75 days after first pruning and a minimum ascorbic acid was recorded in no shoot thinning (170.54 mg/100 g of pulp).

4.3.6 Titrable acidity (%)

Significantly minimum acidity was recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (0.23 %) (Table 16), which was also on par with 75 per cent unproductive tertiary shoot thinning (0.24 %), 50 per cent unproductive tertiary shoot thinning (0.25 %) and 25 per cent unproductive tertiary shoot thinning (0.25 %) at 75 days after first pruning and a highest acidity was recorded in no shoot thinning (0.37 %).

4.3.7 TSS: Acid ratio

TSS: Acid ratio significantly influenced by canopy management practices is presented (Table 16).

TSS: Acid ratio was recorded highest with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (48.12), which was on par with 75 per cent

Table 16. Ascorbic acid (mg/100g of pulp), titrable acidity (%) and TSS: Acid ratio of guava fruit as influenced by canopy management practices

Treatments	Ascorbic acid (mg/100g of pulp)	Titrable Acidity(%)	TSS: Acid ratio
T ₁ - No shoot thinning	170.54	0.37	24.12
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	201.57	0.25	43.30
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	209.26	0.25	44.41
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	218.88	0.24	45.08
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	227.38	0.23	48.12
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	186.73	0.32	30.35
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	184.88	0.32	29.35
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	181.91	0.34	27.61
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	175.22	0.35	25.84
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	178.43	0.34	26.70
S.Em. ±	11.88	0.01	1.63
C.D. (p=0.05)	35.29	0.03	4.84

unproductive tertiary shoot thinning (45.08), 50 per cent unproductive tertiary shoot thinning (44.41) and 25 per cent unproductive tertiary shoot thinning (43.30) at 75 days after first pruning and a lowest TSS: Acid ratio was recorded in no shoot thinning (24.12).

4.3.8 Physiological loss in weight (%)

Significantly minimum physiological loss in weight was recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (Table 17), which was also on par with 75 per cent unproductive tertiary shoot thinning, 50 per cent unproductive tertiary shoot thinning and 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning and a maximum physiological loss in weight was recorded in no shoot thinning.

4.3.9 Shelf life (days)

The data presented in Table 18 revealed that, significantly maximum shelf life was recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (6.54 days), which was found to be on par with 75 per cent unproductive tertiary shoot thinning (6.28 days), 50 per cent unproductive tertiary shoot thinning (6.19 days) and 25 per cent unproductive tertiary shoot thinning (6.07 days) at 75 days after first pruning and a minimum shelf life was recorded in no shoot thinning (5.94 days).

4.3.10 Organoleptic evaluation

Organoleptic evaluation significantly influenced by canopy management practices is presented (Table 18).

The highest organoleptic scores were recorded with 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (9.12, 8.45, 8.68, 8.93 and 8.9 organoleptic scores for colour, firmness, taste, aroma and over all acceptability, respectively), which was also on par with 75 per cent unproductive tertiary shoot thinning (8.75, 8.41, 8.36, 8.82 and 8.75 organoleptic scores for colour, firmness, taste, aroma and over all acceptability, respectively), 50 per cent unproductive tertiary shoot thinning (8.69, 8.38, 8.32, 8.11 and 8.69 organoleptic scores for colour, firmness, taste, aroma and over all acceptability, respectively) and 25 per cent unproductive tertiary shoot thinning (8.48, 8.34, 8.25, 8.09 and 8.49 organoleptic scores for colour, firmness, taste, aroma and over all acceptability, respectively) at 75 days after first pruning and a minimum organoleptic scores were recorded in no shoot thinning (8.07, 8.01, 7.83, 7.68 and 8.01

Table 17. Physiological loss in weight (%) of guava fruit as influenced by canopy management practices

Treatments	Physiological loss in weight (%)					
	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
T ₁ - No shoot thinning	7.84	10.14	11.44	14.14	17.69	19.21
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	6.02	7.39	8.66	10.09	12.73	15.28
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	5.78	7.10	8.06	9.46	11.98	15.05
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	5.35	6.37	7.40	8.70	11.46	14.68
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	4.47	5.08	6.65	8.23	10.42	13.35
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	6.69	8.28	9.85	12.25	14.27	17.50
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	6.86	8.60	10.04	13.19	15.17	17.72
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	7.23	9.08	10.51	13.32	16.34	18.31
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	7.60	9.71	11.27	14.05	17.17	19.08
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	7.36	9.33	10.97	13.79	16.72	18.75
S.Em. ±	0.68	0.90	0.81	0.66	0.89	0.68
C.D. (p=0.05)	2.02	2.67	2.41	1.95	2.66	2.02

Table 18. Shelf life (days) and organoleptic evaluation of guava fruit as influenced by canopy management practices

Treatments	Shelf life (days)	Colour	Firmness	Taste	Aroma	Overall acceptance
T ₁ - No shoot thinning	5.94	8.07	8.01	7.83	7.68	8.01
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	6.07	8.48	8.34	8.25	8.09	8.49
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	6.19	8.69	8.38	8.32	8.11	8.69
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	6.28	8.75	8.41	8.36	8.82	8.75
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	6.54	9.00	8.45	8.68	8.93	8.9
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	6.05	8.32	8.25	8.19	8.04	8.38
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	6.048	8.29	8.21	8.12	8.01	8.29
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	6.02	8.15	8.18	8.08	7.89	8.25
T ₉ - Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	5.98	8.11	8.08	7.98	7.75	8.09
T ₁₀ - Cycocel 500 ppm spray @ 75 days days after first pruning	5.96	8.08	8.03	7.85	7.72	8.12

organoleptic scores for colour, firmness, taste, aroma and over all acceptability, respectively).

4.4 Economics

4.4.1 Total cost (Rs. ha⁻¹)

Total cost of cultivation of guava influenced by canopy management through thinning severity and use of growth retardants is presented in Table 19.

Higher cost of cultivation was recorded with the treatment of 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (₹. 2,09,432 ha⁻¹) followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning (₹. 2,08,432 ha⁻¹). While, lower cost of cultivation was recorded with no shoot thinning (₹. 2,05,182 ha⁻¹).

4.4.2 Gross returns (Rs. ha⁻¹)

The data presented in Table 19 revealed that significantly, higher gross returns (₹. 7,16,250 ha⁻¹) was obtained with treatment 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning. Followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning (₹. 6,60,600 ha⁻¹). Lower gross returns were found in control (₹. 4,06,950 ha⁻¹).

4.4.3 Net returns (Rs. ha⁻¹)

There was significant differences in net returns by canopy management through thinning severity and use of growth retardants (Table 19).

Significantly higher net returns was found in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (₹. 5,06,818 ha⁻¹) followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning (₹. 4,52,168 ha⁻¹). However, lower net returns were found in no shoot thinning (₹. 2,01,768 ha⁻¹).

4.4.4 Benefit cost (B: C) ratio

Significantly the higher benefit cost ratio was recorded with the treatment 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (3.42) (Table 19), followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning (3.17). Lower benefit cost ratio was recorded in no shoot thinning (1.98).

Table 19. Economics of growing of fruits of guava as influenced by canopy management practices

Treatments	Treatment cost (Rs./ha)	Other cost (Rs./ha)	Total cost (Rs./ha)	Gross returns (Rs./ha)	Net Returns (Rs./ha)	B:C ratio (Rs./ha)
T ₁ - No shoot thinning	00	205,182	205,182	406,950	201,768	1.98
T ₂ -25 % unproductive tertiary shoot thinning @ 75 days after first pruning	1750	205,182	206,932	624,600	417,668	3.02
T ₃ -50 % unproductive tertiary shoot thinning @ 75 days after first pruning	2500	205,182	207,682	645,450	437,768	3.11
T ₄ -75 % unproductive tertiary shoot thinning @ 75 days after first pruning	3250	205,182	208,432	660,600	452,168	3.17
T ₅ -100 % unproductive tertiary shoot thinning @ 75 days after first pruning	4250	205,182	209,432	716,250	506,818	3.42
T ₆ - Unproductive tertiary shoot pruning @ 75 days after first pruning	3000	205,182	208,182	514,200	306,018	2.47
T ₇ - Unproductive tertiary shoot pruning @ 90 days after first pruning	3000	205,182	208,182	485,550	277,368	2.33
T ₈ - Unproductive tertiary shoot pruning @ 105 days after first pruning	3000	205,182	208,182	471,450	263,268	2.26
T ₉ -Paclobutrazol 1000 ppm spray @ 75 days days after first pruning	1820	205,182	207,002	450,450	243,448	2.18
T ₁₀ -Cycocel 500 ppm spray @ 75 days days after first pruning	1420	205,182	206,602	461,100	254,498	2.23



Plate. 4 Fruiting potential of plant under experimental plot

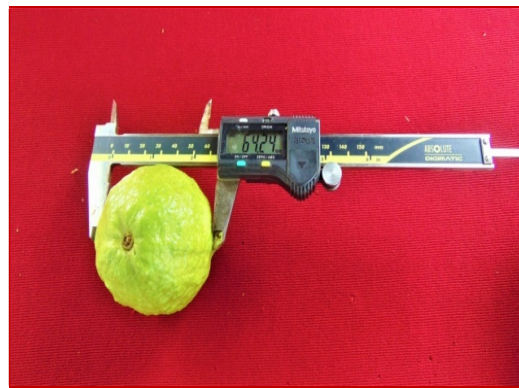


Plate. 5 Fruit length and breadth under experimental plot

V. DISCUSSION

The experiment was conducted at Horticulture farm Main Agricultural Research Station, UAS Raichur, Karnataka during year 2017-18 to study the effect of canopy management under high density guava. The results of the investigation are discussed in this chapter.

5.1 Influence of weather on crop performance

Crop growth is mainly dependent on environmental factors, soil and climate, the associated crops and the management (Thomas 2003). In general, the soil characteristics Corwin *et al.* (2003) and weather conditions Mwale *et al.* (2007) greatly influence the growth and development and yield potential of crops. In particular, the research station where the present investigation was carried out falls in North Eastern Dry Zone of Karnataka characterized dry climate with uncertain and erratic rainfall and low moisture retentive soils. Plant did not experience moisture stress as they were supplemented with drip irrigation during dry spells. The crop was free from major pest and diseases as necessary plant protection measures were taken. The temperature and relative humidity were near normal during the experiment period. During crop growth period mean monthly maximum temperature was ranged from 29.7°C (December) to 34.8°C (June) while, the mean minimum temperature ranged from 16.2°C (December) to 24.6°C (June) and found that there was no much deviation in mean maximum and minimum temperature from the normal. The mean relative humidity was highest during October (92 %) and the lowest in July (78 %).

5.2 Effect of canopy management on yield and yield attributes

The deference in fruit yield of guava due to canopy management by shoot thinning and use of growth retardant, however, unproductive tertiary shoot thinning practices were found significant. The study conducted in the recent past revealed that severity of thinning in guava produce higher yield (Sathya Prakash, 2012)

In the present study the results revealed that, yield was maximum in severity of unproductive shoot thinning treatment, 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (47.75 t ha⁻¹) followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning (44.04 t ha⁻¹) and 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning (43.03 t ha⁻¹) along with 25 per cent

unproductive tertiary shoot thinning at 75 days after first pruning (41.64 t ha^{-1}) (Fig. 5). The results attributed to improvement in yield by canopy management through unproductive shoot thinning, it might be due to the fact that unproductive shoots utilized stored carbohydrates and available nutrients in the soil, which might have been diverted into productive shoots and fruits of the plant. Similar results agreement with Pankaj *et al.* (2016). Smaller fruit size and lesser fruit weight in no shoot thinning treatment might be due to more competition between source (leaves) and sink (fruits) absorbing carbohydrates reserves for their growth and development, rate of photosynthesis might also be reduced due to lesser penetration of light and limited leaf area and lower leaves did not receive the significant amount of light for photosynthesis as compared to shoot thinning treatments. Similar results were reported by Pratibha and Shant Lal (2012). The fruit weight was found maximum in pruning and deblossoming levels, is probably due to the chances of light penetration is freely inside the canopy. So it might be possible that net photosynthesis increased and maximum reserves were collected in the trees which finally utilized by the fruits during their growth and development. Those reserves were utilized by the fruits which helped them to attain increased fruit weight. Islam *et al.* (1992) found that guava thinned plants produced larger and heavier fruits than unthinned trees. Maximum fruit diameter was found with severe pruning. Similar, results were noticed earlier by Syamal and Rajput (1989) in ber and Sheikh and Rao (2002) in pomegranate.

Bagchi *et al.* (2008) reported a consistent increase in concentrations of tryptophan, proline, polyphenol oxidase, catalase and peroxidase levels in leaves, bark, and fruit of the guava tree and decreased in phenolics concentration after pruning. Such chemical changes, especially proline biosynthesis, in plants parts after pruning may have contributed to higher flowering and fruiting in the winter, resulting in a higher yield in winter per plant. Confirming the results from previous studies in which Shukla *et al.* (2009) observed a higher winter yield in pruned trees. The pruning treatments not only produced more winter season crop but also the total yield as compared to control. This seems to be because of production of large number of flowering shoots, diversion of stored food materials for healthy shoots, flowering after rainy season crop, better flowering and higher fruit set and lastly improved the light environment of the canopy which is helpful in flower production on new shoots (Singh *et al.*, 2001). The increase in fruit weight would have due to utilization of whole food materials among the fewer fruits

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

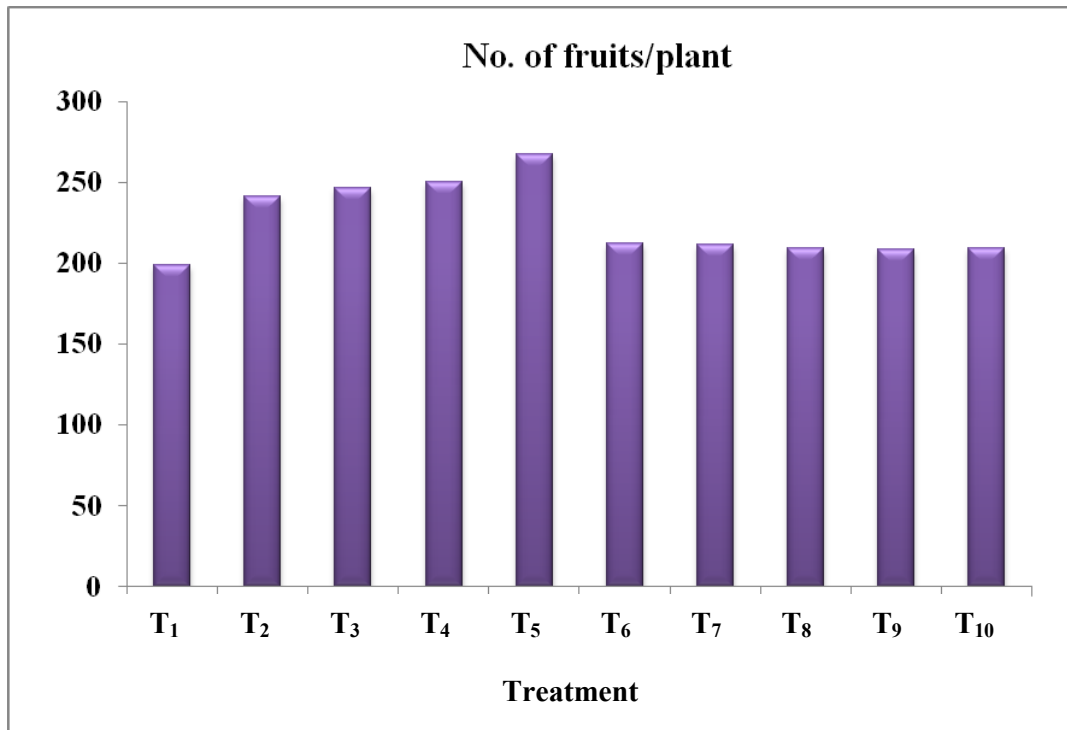


Fig. 2 Number of fruits per plant of guava as influenced by canopy management practices

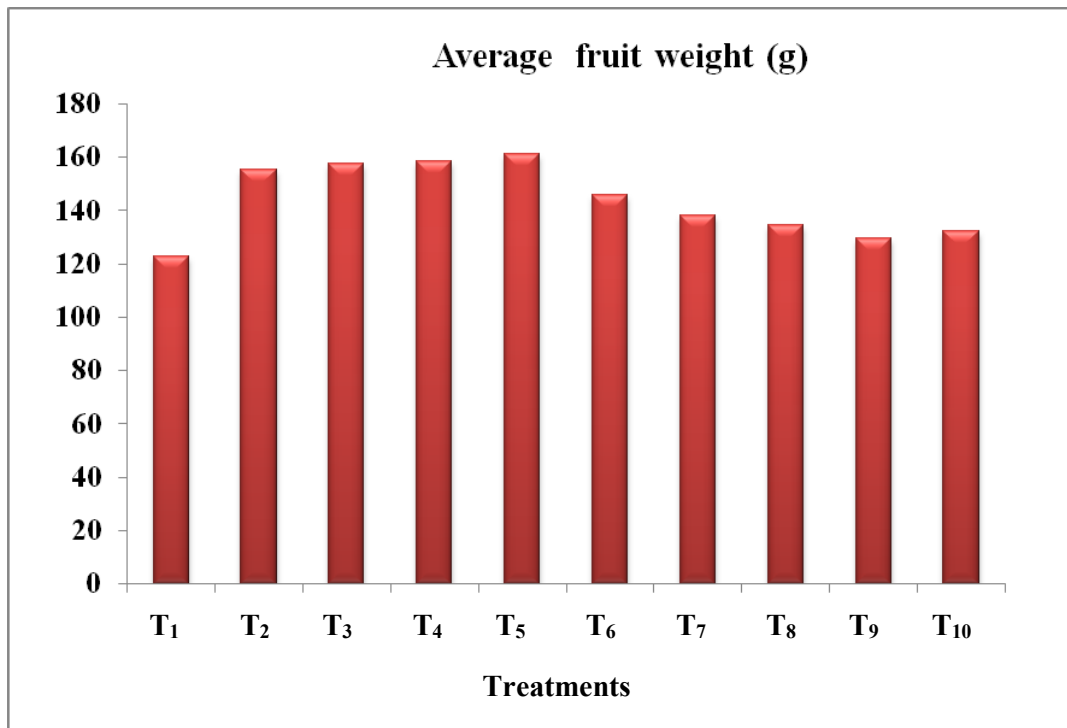


Fig. 3 Average fruit weight (g) of guava as influenced by canopy management practices

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

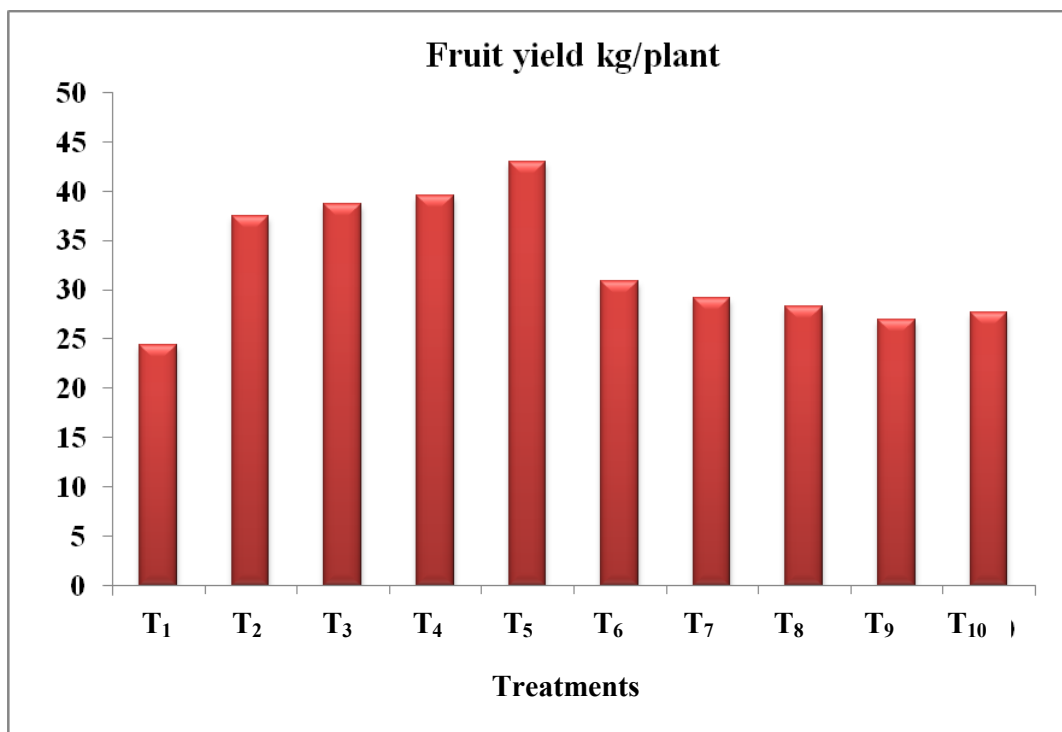


Fig. 4 Fruit yield kg plant^{-1} of guava as influenced by canopy management practices

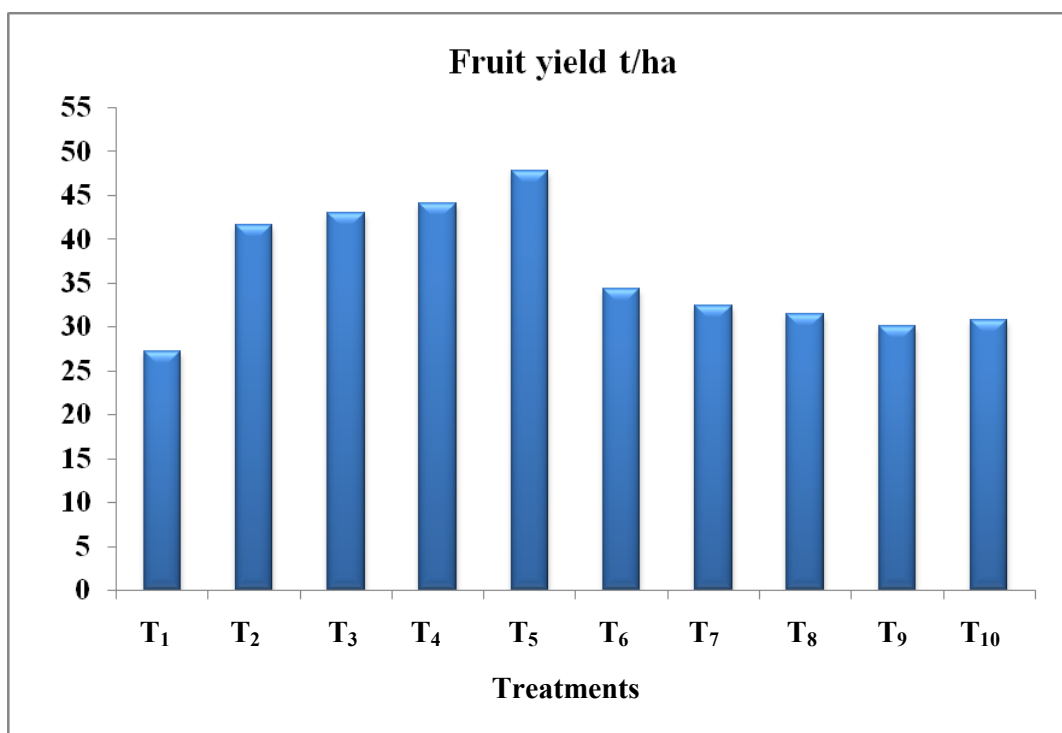


Fig. 5 Fruit yield (t ha^{-1}) of guava as influenced by canopy management practices

recorded under severe pruned trees. Similar results are obtained earlier by Bajpai *et al.* (1973) in guava. Shanmugavelu and Selvarajan (1985) reported that, pruning and thinning of mango cultivars gave higher yield than the yield of un-pruned trees. Rajendra *et al.* (1980) reported that, increase in the severity of pruning increased the total yield per tree by way of producing bigger fruits in apple. Sathya Prakash *et al.* (2012) noted that highest fruit yield (kg tree⁻¹) was obtained with severely pruned trees of guava. The increase in diameter may be attributed to the reduction in crop load and pruning severity, which in turn diverted more nutrients to the remaining fruits, thereby improving the size of fruits. These results were found by Gurudarshan Singh and Dhaliwal (2004) in guava and Jozsef Racsko (2006) in apple. Severe pruning resulted in increases the vegetative growth and fruit yield in guava (Singh, 2012). Maximum fruit yield in guava at 50 per cent canopy pruning. These findings were in close conformity with findings of Pilania *et al.* (2010). Highest photosynthesis rate was found in shoot-thinning, followed by shoot pinching compared to the Control. Similar results reported by Koblet (1975) and Hunter and Visser (1988) who concluded that changes in canopy microclimate, increases photosynthetic activity and export photo assimilates. However, in this study, enhancement of photosynthetic activity due to improved light intensity was found to have a positive effect on yield. Kumar and Rattanpal (2010) studied that in guava, the total fruit yield and yield per hectare were the highest in pruning treatment of half removal of vegetative growth.

5.3 Effect of canopy management on growth and growth attributes

The differences in fruit yield in guava as influenced by canopy management through shoot thinning and use of growth retardants, related to variation in vegetative growth throughout the crop growth period after pruning, the major growth attributes of guava viz., plant height, canopy spread, length of new shoot, girth of new shoot, canopy volume, leaf area index, light interception, SPAD readings, transpiration rate and net photosynthetic rate (Fig. 6-15.). Significant differences in growth parameters was observed at 120, 150 and 180 days after first pruning in the treatment 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning (T₅) followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning (T₄) and 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning (T₃) along with 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning (T₂).

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

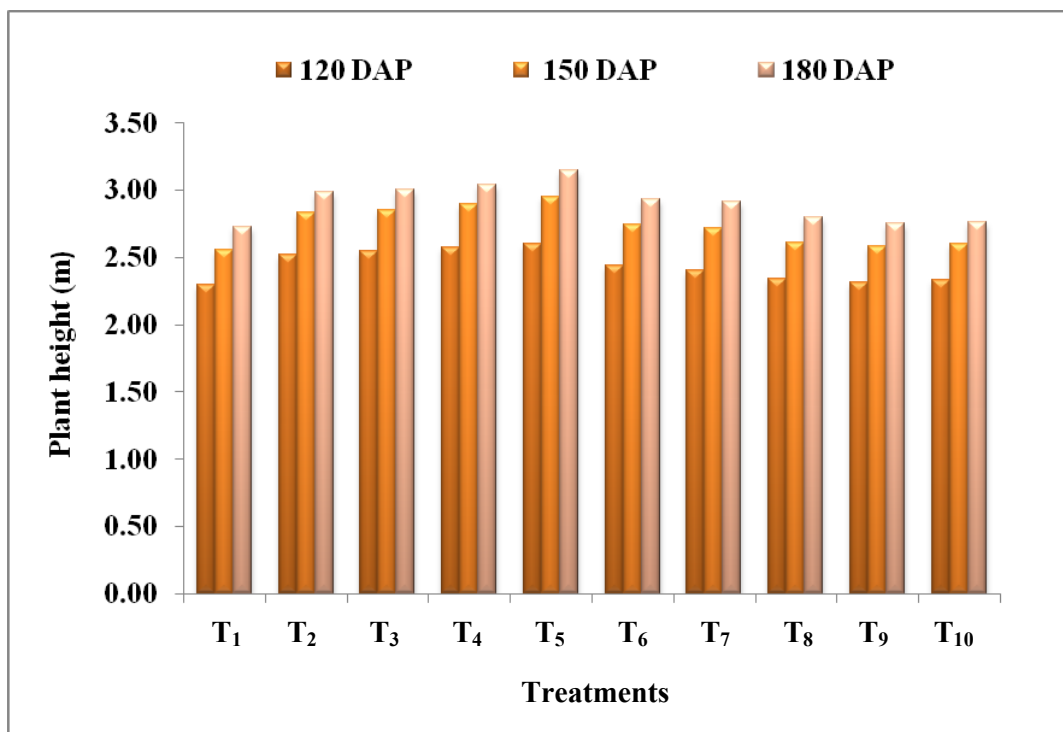


Fig. 6 Plant height (m) of guava at different growth stages as influenced by canopy management practices

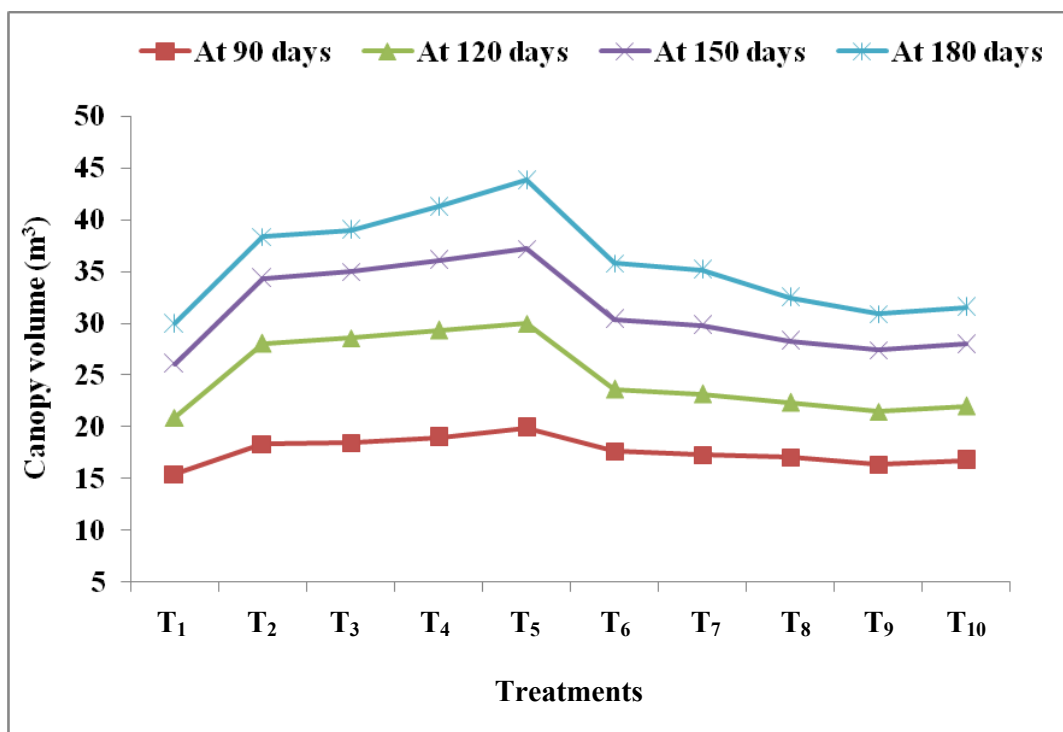


Fig. 7 Canopy volume (m³) of guava at different growth stages as influenced by canopy management practices

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

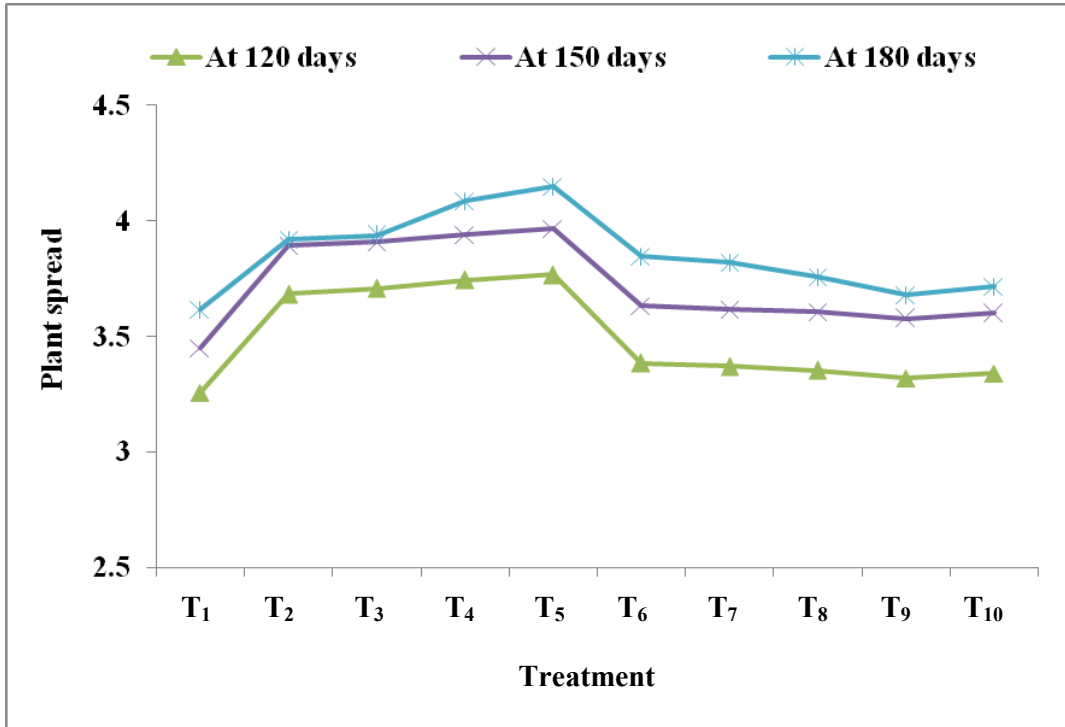


Fig. 8 Plant spread in E-W direction (m) of guava at different growth stages as influenced by canopy management practices

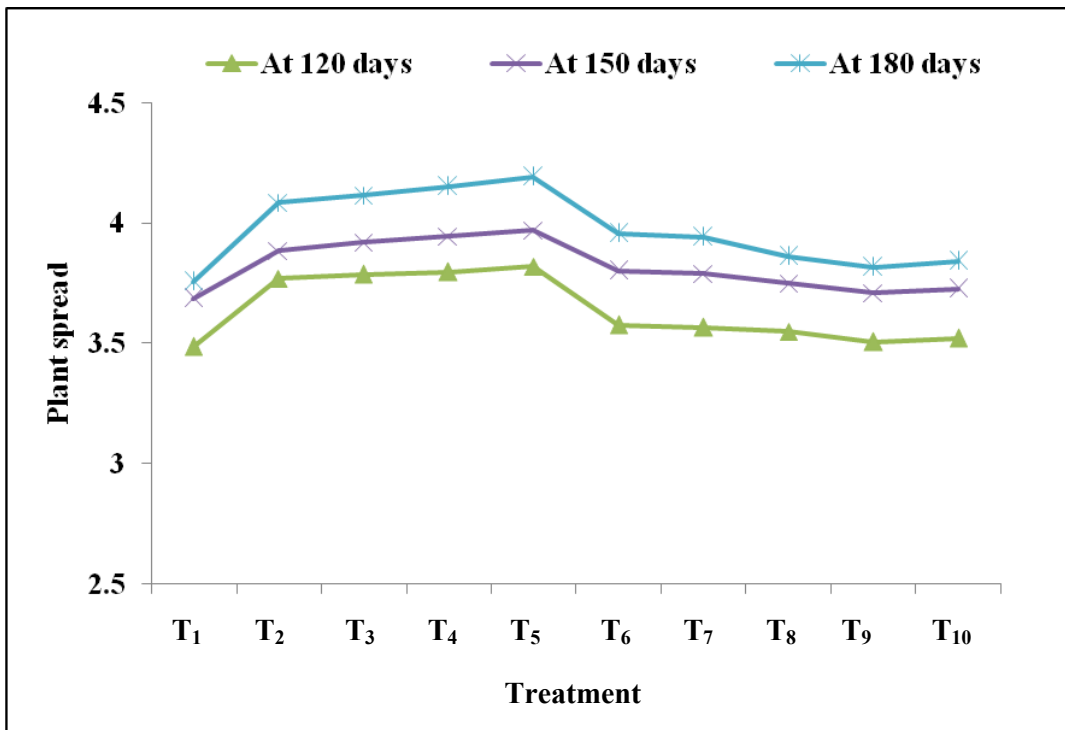


Fig. 9 Plant spread in N-S direction (m) of guava at different growth stages as influenced by canopy management practices

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

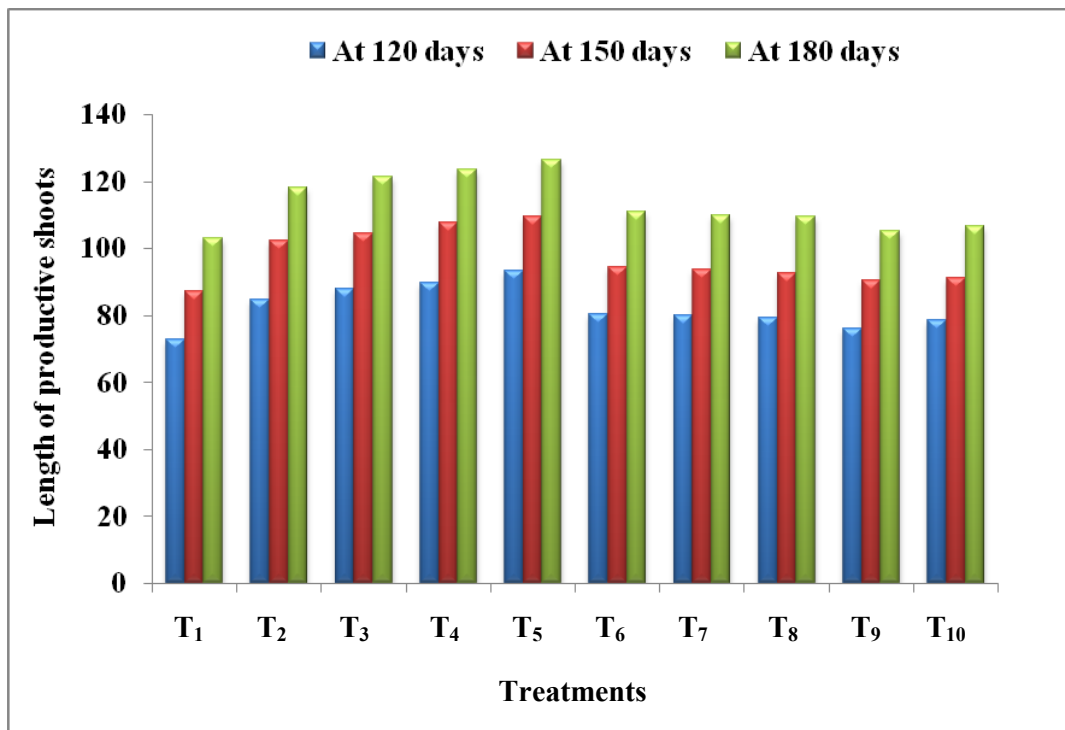


Fig. 10 Length of productive shoots (cm) of guava at different growth stages as influenced by canopy management practices

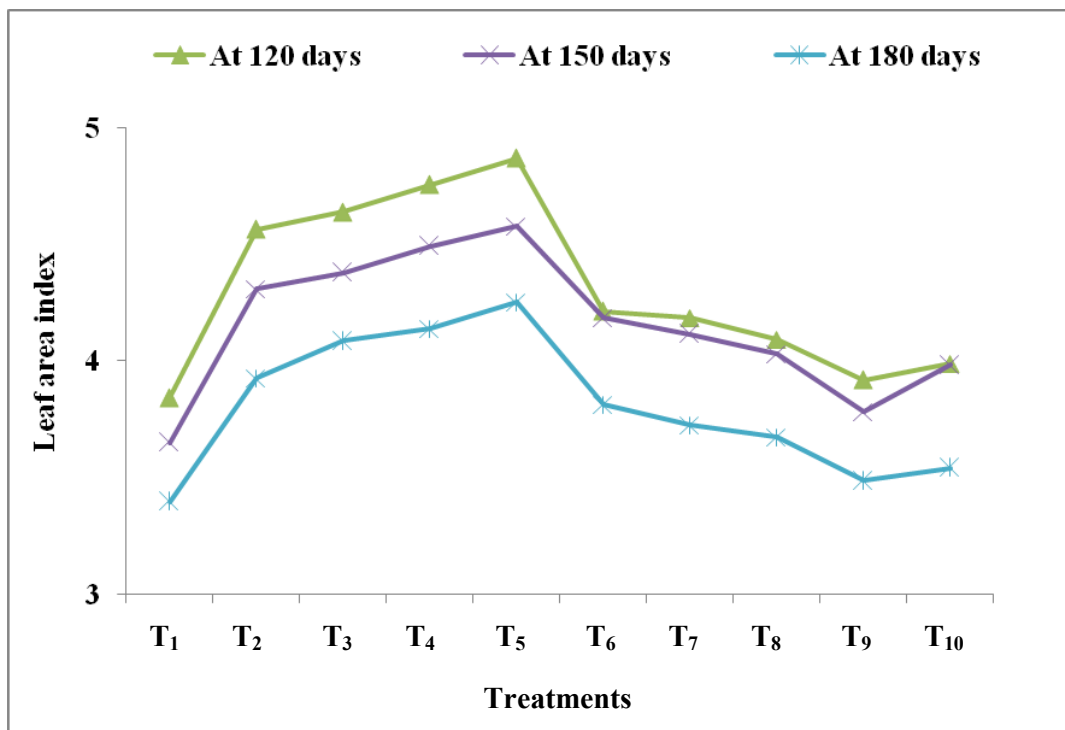


Fig. 11 Leaf area index of guava at different growth stages as influenced by canopy management practices

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

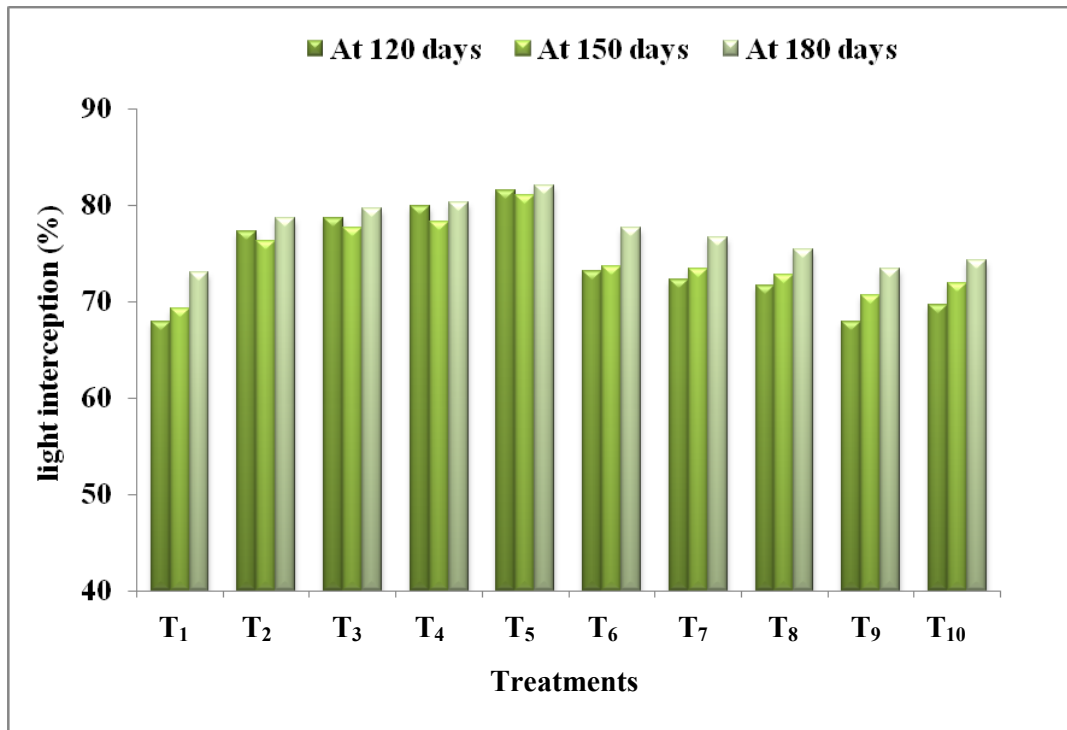


Fig. 12 Light interception % of guava at different growth stages as influenced by canopy management practices

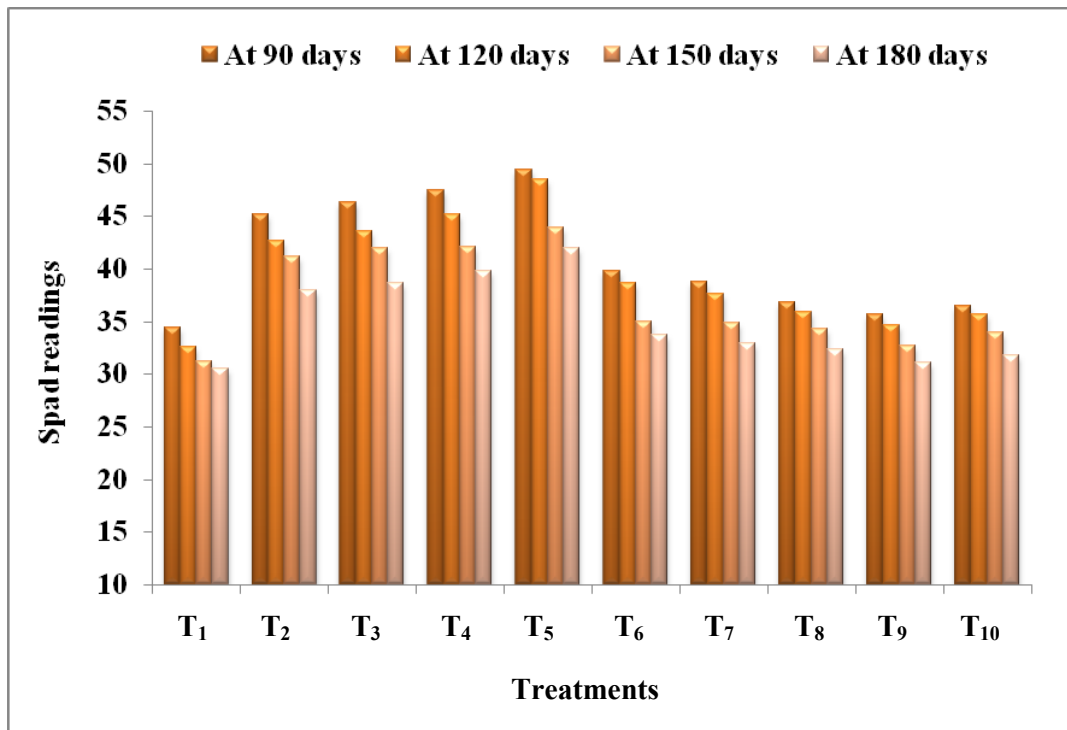


Fig. 13 Chlorophyll meter readings (SPAD) of guava at different growth stages as influenced by canopy management practices.

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

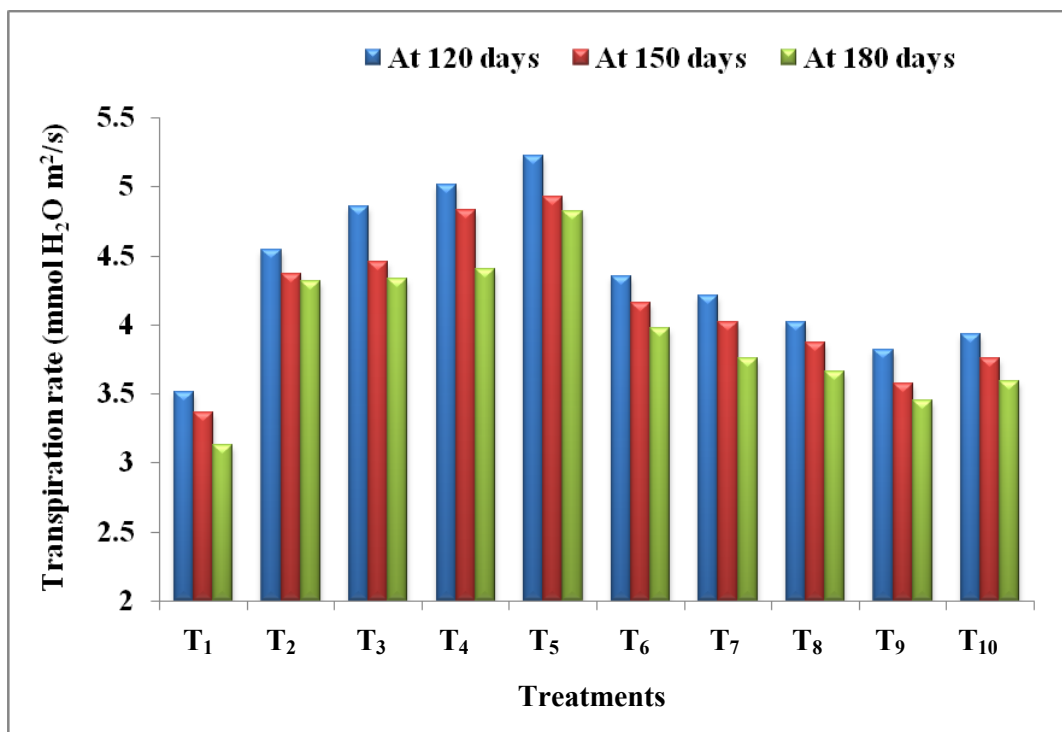


Fig. 14 Transpiration rate ($\text{m mol H}_2\text{O m}^{-2} \text{s}^{-1}$) of guava at different growth stages as influenced by canopy management practices

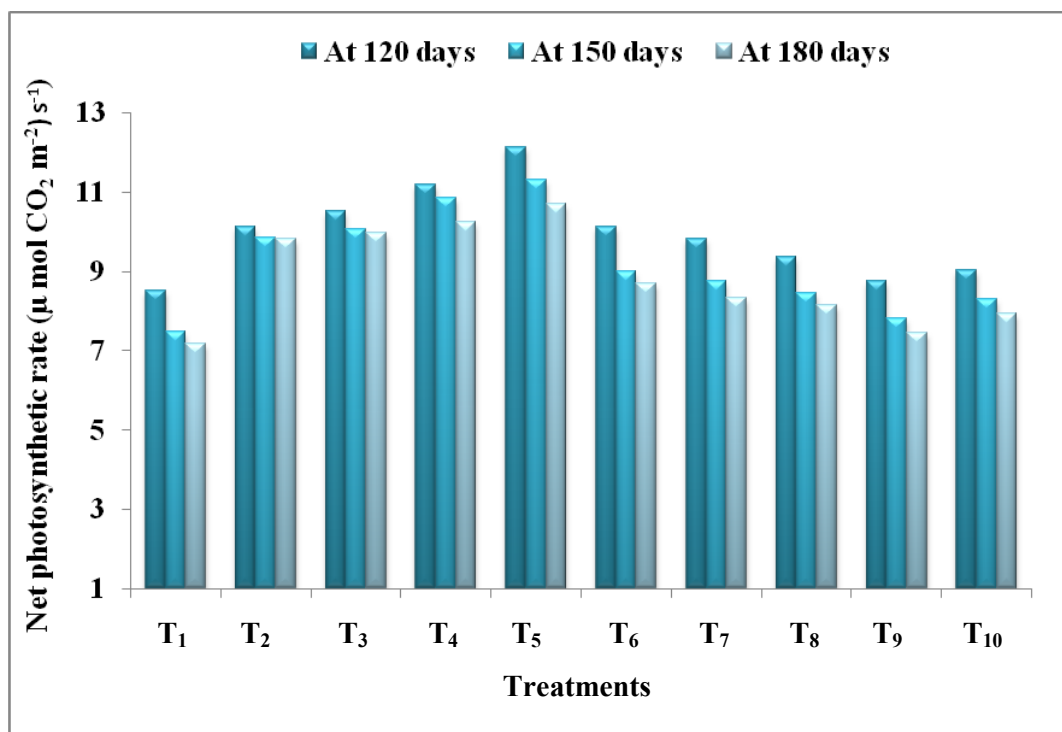


Fig. 15 Net photosynthetic rate ($\mu \text{mol CO}_2 \text{m}^{-2} \text{s}^{-1}$) of guava at different growth stages as influenced by canopy management practices

According to Rodrigues da Silva *et al.* (2016), the guava tree is very well respond to pruning and new shoots arise after branch cutting. In general, a faster emergence of new shoots and branch establishment means a shorter time for bloom occurrence. The magnitude of variation in individual growth parameters vary throughout the crop growth period. The present study indicated that canopy management through unproductive shoot thinning helps to grow plant vigorously as indicated by higher plant height, plant spread and canopy volume. Removal of unproductive shoots had a significant influence on growth and growth attributes, might be due to that, unproductive shoots utilized the stored carbohydrates and available nutrients in the soil, which might have been diverted for growth of productive shoots of plant. Similar results also reported by Pankaj *et al.* (2016), Prabhakar *et al.* (2016). Defoliating trees partially increases the rate of photosynthesis in the remaining leaves because they provide a relatively larger sink and this depends on the defoliation degree (Kozlowski and Pallardy, 1997). In pruning, it is important to cut off (thinning) upright water sprouts which direct photosynthates, among other substances, to the growing shoot tip at the expense of reproductive growth Anuradha *et al.* (2017). Thinning of shoots is effective for the penetration of solar radiation near the trunk in the crown (Mizutani, 2011). Net photosynthesis was found maximum in pruning, is probably due to the chances of light penetration is freely inside the canopy. So it might be possible that net photosynthesis increased and maximum reserves were collected in the trees which finally utilized by the fruit during their growth and development. Similar readings found that, Lal *et al.* (2007), (Singh and Singh, 2007). Maximum shoot length was recorded with severely pruned trees was noted earlier by Shaban and Haseeb (2009); Jadhav *et al.* (2002); Gopikrishna (1980) and Bajpai *et al.* (1973) in guava. The increase in growth was primarily a function of greater availability of photosynthates and the nutrients in the heavily pruned trees due to proportionate reduction in number of vegetative buds which were likely to develop into new shoots thereby, reducing competition for carbohydrates and other metabolites. These results are in agreement with Said and Ali (1989). The LAI in conjunction with sunlight interception is useful as a basis for analyzing canopy productivity (Fischer, 2011).

5.4 Effect of canopy management on quality attributes

The performance of guava with respect to quality parameters *viz.*, total soluble solids, TSS: Acid ratio, sugars, titrable acidity, ascorbic acid, shelf life, physiological loss in weight and organoleptic evaluation (Fig. 16-19). Canopy management was

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days after first pruning

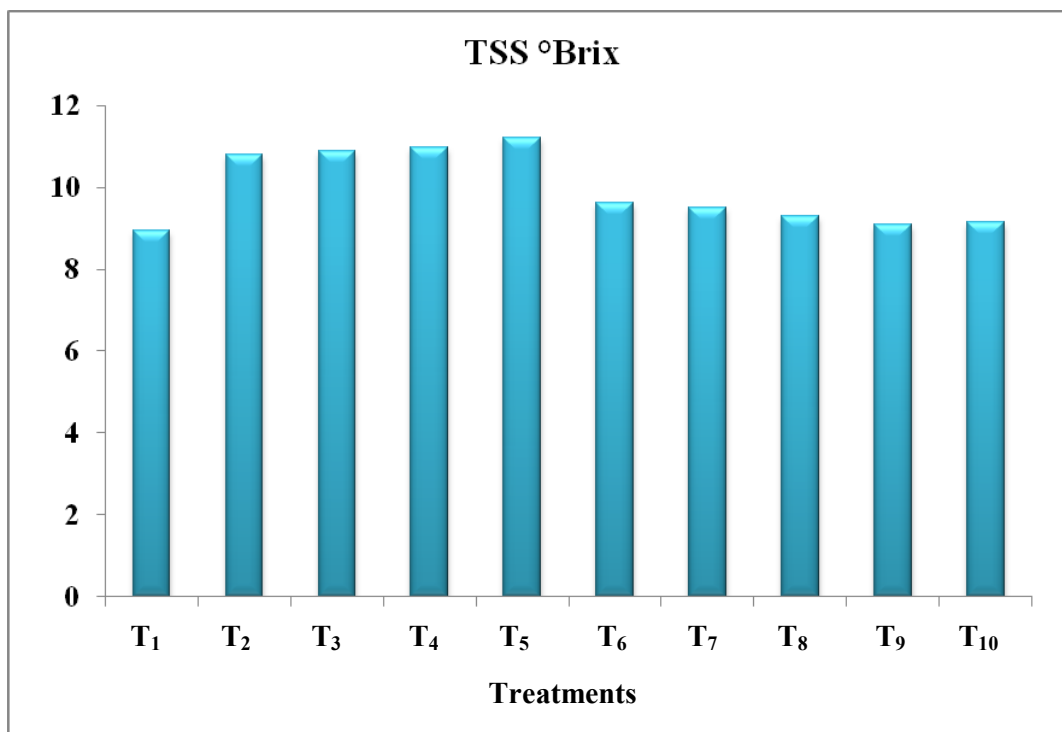


Fig. 16 TSS °Brix of guava fruit as influenced by canopy management practices

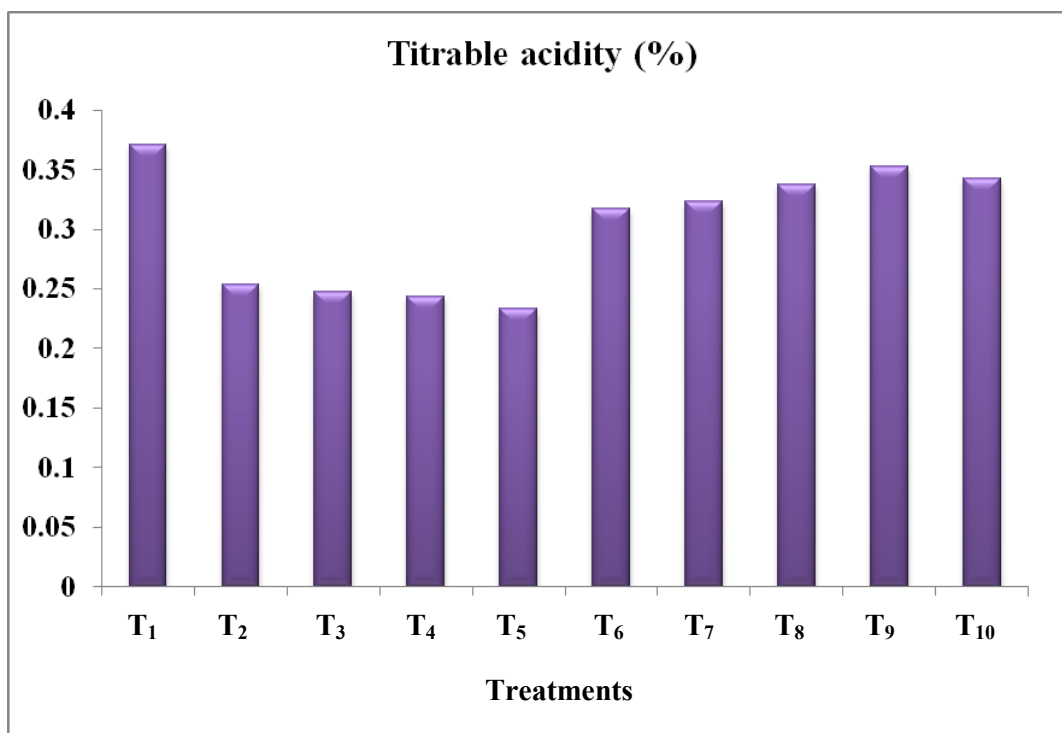


Fig. 17 Titrable acidity (%) of guava fruit as influenced by canopy management practices

LEGEND

T₁- No shoot thinning

T₂- 25 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₃- 50 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₄- 75 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₅- 100 % unproductive tertiary shoot thinning @ 75 days after first pruning

T₆- Unproductive tertiary shoot pruning @ 75 days after first pruning

T₇- Unproductive tertiary shoot pruning @ 90 days after first pruning

T₈- Unproductive tertiary shoot pruning @ 105 days after first pruning

T₉- Paclobutrazol 1000 ppm spray @ 75 days days after first pruning

T₁₀- Cycocel 500 ppm spray @ 75 days days after first pruning

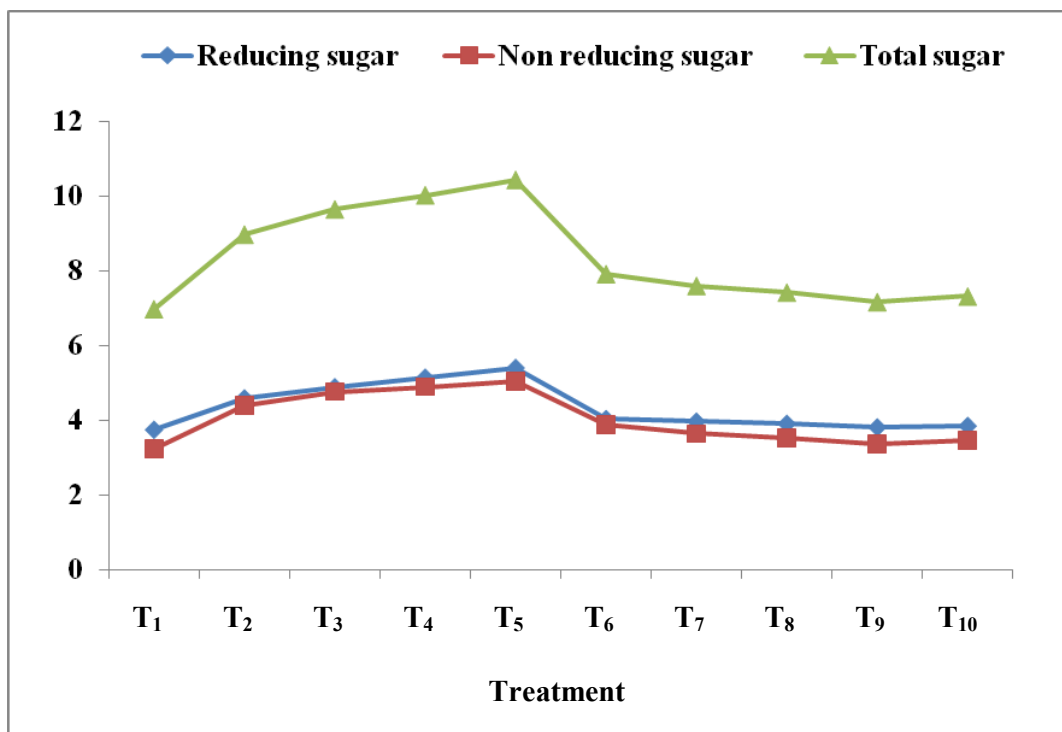


Fig. 18 Reducing (%), non reducing (%) and total sugars (%) of guava fruit as influenced by canopy management practices

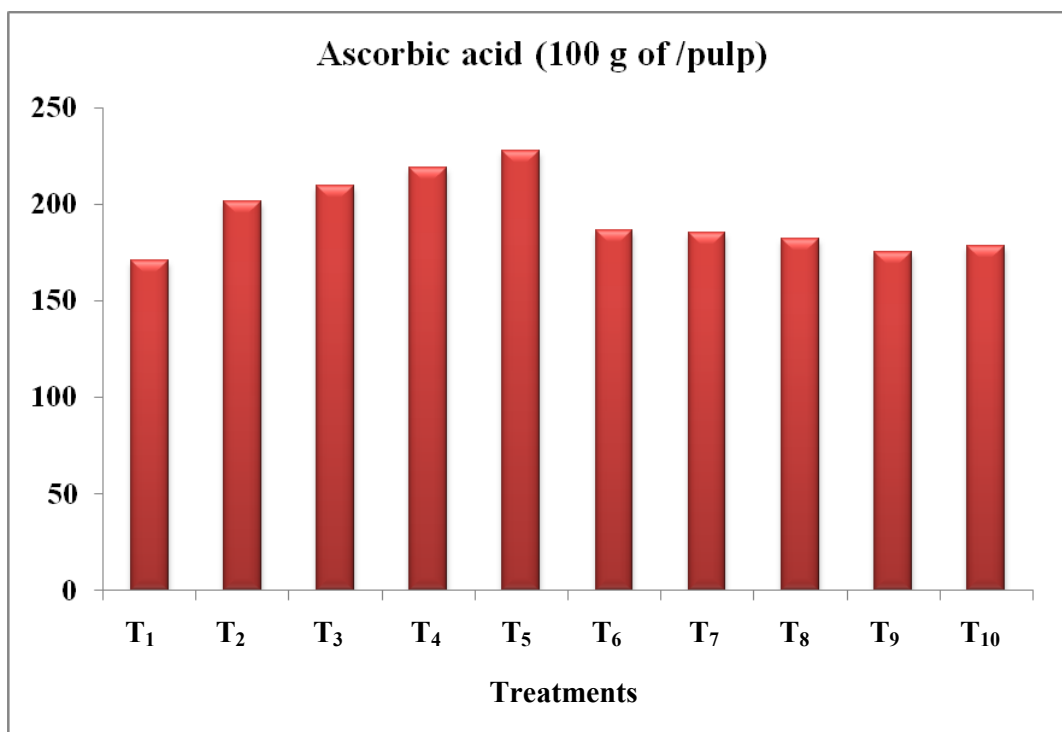


Fig. 19 Ascorbic acid (100 g of / pulp) of guava fruit as influenced by canopy management practices

significantly influenced on quality of fruits through severity of unproductive shoot thinning. It might be due to that, less competition of reserve food and nutrients uptake in the plants and fruits. Good quality fruits in pruned plants with complete removal of non fruiting shoots (Pankaj *et al.* 2016). Similar results were also found with Prabhakar *et al.* (2016). More distribution of light in plant systems not only effects fruit yield but also effects size, quality and colour of the fruits. The dense foliage in unpruned plants resulted in shading its lower canopy there by affecting the photosynthesis and reduction in carbohydrate production. Without pruning was attributed poor quality of fruits because uneven and poor penetration of sunlight. However, the results obtained in present investigation showed that, the observed quality of fruits from high density plantation with severity of unproductive shoot thinning. Pankaj *et al.* (2016) reported that, for obtaining higher winter season crop and enhanced fruit quality under high density planting of guava, complete removal of non fruiting shoots followed by one leaf pair shoot pruning of current season growth.

Thinning in the early stages of fruit growth increases size of remaining fruits. as a result of fruit load, the fruit quality of the winter crop got improved producing more sugars, TSS and ascorbic acid whereas acidity of the fruit was decreased. Fruit size, fruit weight and organoleptic values were also found improved as compared to control (Tahir and Kamran Hamid, 2002). Quality fruit is function of absorption of light and light is directly proportional to the yield of fruit trees (Jackson, 1980).

5.5 Economics

Economic analysis of guava cultivation canopy management practices indicate that the highest gross and net returns with the treatment of 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning. Further, lower return was obtained in no shoot thinning, mainly because lower fruit yield. The treatment 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning recorded highest B: C ratio was mainly because of higher gross return. Similar results were reported by Tiwari and Lal (2007). The pruning intensity obtained maximum B: C at 50 per cent canopy (Tabin *et al.*, 2015).

5.6 Practical utility of experiment

The result obtained in present investigation revealed the following practical utilities in promoting best canopy management practice through unproductive shoot thinning for getting maximum fruit yield and quality of guava under high density planting.

5.7 Future line of work

1. Canopy management studies under various density with nutrient management needs further work.
2. Crop regulation need to be conducted by restricting the number of fruits per plant in high density for getting quality fruits.
3. Further research required on level and date of pruning under high density planting.



Plate. 3: Elite treatments under experimental plot

VI. SUMMARY AND CONCLUSION

The present investigation was carried out at Main Agricultural Research Station, University of Agriculture Sciences, Raichur, Karnataka, during 2017-18 to study the effect of canopy management in high density guava. The results obtained from the study are summarised under this chapter.

The canopy management practices had significant influence on most of the growth, yield and quality parameters of high density planting guava. The treatment 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning has resulted in the maximum plant height (2.60, 2.95 and 3.15 m), plant spread in East-West (3.77, 3.97 and 4.15 m), plant spread in North-South (3.82, 3.97 and 4.19 m), length of new shoots (93.33, 109.39 and 126.31 cm), girth of new shoot (1.15, 1.46, and 1.64 cm), leaf area index (4.87, 4.58 and 4.25), light interception (81.48, 80.98 and 82.01 %), transpiration rate (5.22, 4.93 and 4.82 $\text{m mol H}_2\text{O m}^{-2} \text{s}^{-1}$) and net photosynthetic rate (12.12, 11.31 and 10.71 $\mu \text{mol CO}_2 \text{m}^{-2} \text{s}^{-1}$) at 120, 150 and 180 days after pruning. However, canopy volume (19.92, 29.96, 37.19 and 43.80 m^3) and SPAD meter readings (49.35, 48.45, 43.95 and 41.92) were recorded maximum at 90, 120, 150 and 180 days after pruning. Which was also on par with 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning, 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning and 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning.

The yield and yield attributes were significantly influenced by canopy management through unproductive shoot thinning. Highest number of fruit (267.07), average fruit weight (161.23 g), fruit diameter (6.30 cm), fruit length (7.15 cm), fruit yield per plant (42.98 kg) and fruit yield per hectare (47.75 ton) were observed in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning, which was also on par with 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning, 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning and 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning.

Significant differences were found with regard to quality parameters. However, significantly higher total soluble solids (11.21 $^{\circ}\text{Brix}$), TSS: Acid ratio (48.12), reducing sugar (5.40 %), non reducing sugar (5.04 %), total sugar (10.43 %), titrable acidity (0.23 %) and ascorbic acid (227.38 mg/100g of pulp) in the treatment 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning. It was also on par with

75% unproductive tertiary shoot thinning at 75 days after first pruning, 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning and 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning.

During the storage period, significant difference was recorded with physiological loss in weight, shelf life and overall acceptability of fruit in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning. It was also on par with 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning, 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning and 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning.

Higher gross return (Rs. 7,16,250 ha⁻¹), net return (Rs. 5,06,818 ha⁻¹) and benefit cost ratio (3.42) was recorded in 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning. Followed by 75 per cent unproductive tertiary shoot thinning at 75 days after first pruning and 50 per cent unproductive tertiary shoot thinning at 75 days after first pruning along with 25 per cent unproductive tertiary shoot thinning at 75 days after first pruning.

Conclusion

The result of present experiment shows that 100 per cent unproductive tertiary shoot thinning at 75 days after first pruning which was appropriate canopy management for obtaining optimum vegetative growth, yield and improve the quality of the fruits and also maximum net income (Rs. 5,08,818 ha⁻¹) with B:C (Rs 3.42) under high density planting.

VII. REFERENCES

- A. O. A. C., 1970, Official method of analysis of the association of official analytical chemist, 11th Edn., Washington, D. C.
- Adhikaria, S. and Kandelb, T. P., 2015, Effect of time and level of pruning on vegetative growth, flowering, yield and quality of guava. *Int. J. Fruit Sci.*, 00: 1-12.
- Agarwal, S. and Dikshit, S. N., 2008, Studies on the effect of plant growth regulators on growth and yield of Sapota (*Achras sapota* L.) cv. Cricket Ball. *Indian J. Agric. Res.*, 42(3): 207-211.
- Ali, Sahar, F. and Abdel-Hameed, A. A., 2014, Effect of pruning on yield and fruit quality of guava trees. *IOSR J. Agric and Veterinary Sci.*, 7(12): 41-44.
- Anonymous, 2017, Indian Horticulture Database. NHB, Haryana. <http://www.nhb.gov>
- Anuradha, R. K., Goyal and Bishnoi, C., 2017, Assimilate partitioning and distribution in fruit crops: A review. *J. Pharmacognosy and Phytochemistry.*, 6(3): 479-484.
- Bagchi, T. B., Sukul, P. and Ghosh, B., 2008, Biochemical changes during off-season flowering in guava (*Psidium guajava* L.) induced by bending and pruning. *J. Trop. Agr.*, 46(1-2): 6-6.
- Bajpai, P. N., Shukla, H. S. and Chaturvedi, A. M., 1973, Effect of pruning on growth, yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Progressive Hort.*, 5(1): 73-79.
- Bhujbal, D. S., Naik, D. M. and Kale, S. A., 2012, Effect of growth regulators on growth and yield of sapota [*Manilkara achras* (Mill.) Forsberg]. *Asian J. Hort.*, 7(2): 351-353.
- Brar, J. S. and Bal, J. S., 2010, Role of paclobutrazol and ethephon in reproductive growth of 'Allahabad Safeda' guava (*Psidium guajava* L.) plants at different spacing. *J. Hortl. Sci.*, 5(2): 128-133.
- Brar, J. S., 2010, Influence of paclobutrazol and ethephon on vegetative growth of guava (*Psidium guajava* L.) plants at different spacing. *Not. Sci. Biol.*, 2(3): 110-113.

- Brar, J. S., Dhaliwal, H. S. and Bal, J. S., 2012, Influence of paclobutrazol and ethephon on fruit quality of 'Allahabad safeda' guava. *HortFlora Research Spectrum*, 1(2): 135-138.
- Brar, J. S., Dhaliwal, H. S., Bal, J. S., Dhillon, W. S. and Singh, S. P., 2012, Effect of spacing on canopy microclimate, vegetative growth and yield attributes in guava (*Psidium guajava* L.) *J. Hort. Sci.*, 7(1): 41-45.
- Corwin, D. L. and Lesch, S. M., 2003, Application of soil electrical conductivity to precision agriculture: Theory, principles and guidelines. *Agron. J.*, 95(3): 455-471.
- Dalal, R. P. S., Sangwan, A. K., Beniwal, B. S. and Sharma, S., 2013, Effect of planting density on canopy parameter, yield and water use efficiency of Kinnow mandarin. *Indian J. Hort.*, 70(4): 587-590.
- Das, B. and Jana, B. R., 2012, Effect of canopy management on growth and yield of mango cv. Amrapali planted at close spacing. *J. Food. Agric. Env.*, 10(3&4): 328-331.
- Deshmukh, N. A., Rymbai, H., Jha, A. K., Lyndon, P. and Malhotra, S. K., 2017, Effect of thinning time and fruit spacing on fruit maturity, yield, size, peel colour and quality attributes of peach cv. Flordasun. *Indian J. Hort.*, 74(1): 45-50.
- Dinesh, M. R. and Vasugi, C., 2010, Guava improvement in India and future needs. *J. Hort. sci.*, 5(2): 94-108.
- Fischer, G., 2011, La relación hoja/fruto en especies frutícolas.. Proc. 4th Colombian Congress of Horticulture, Palmira, Colombia. pp. 40-53
- Gaikwad, S. P., Chalak, S. U. and Kamble, A. B., 2017, Effect of spacing on growth, yield and quality of mango. *J. Krishi Vigyan.*, 5(2): 50-53.
- Gopikrishna, N. S., 1980, Studies on the effect of pruning on vegetative growth, flowering and fruiting in 'Sardar' guava (*Psidium guajava* L.) *M.sc. Thesis*, Uni. Agric. Sci., Dharwad.
- Gopu, B., Balamohan, T. N., Swaminathan, V., Jeyakumar, P. and Soman, P., 2017, Effect of growth retardants on yield and yield contributing characters in mango (*Mangifera indica* L.) cv. Alphonso under ultra high density plantation. *Int. J. Curr. Microbiol. App. Sci.*, 6(11): 3865-3873.

- Gopu, B., Balamohan¹, T. N. Soman, P. and Jeyakumar, P., 2014, Canopy management in mango (*Mangifera indica* L.) cv. Alphonso with reference to flowering, yield and quality characters under ultra high density planting. *J. App. Hort.*, 16(1): 50-53.
- Gorakh Singh, 2001, High density planting in guava. Annual Report, *Central Institute of Subtropical Horticulture*, Lucknow.
- Gorakh Singh, 2011, Application of canopy architecture in high density planting in guava. *Progressive Hortl.*, 43(1): 36-43.
- Gupta, N. and Gil, M. S., 2015, Effect of intensity of pruning on yield and fruit quality of ber (*Ziziphus mauritiana* L) cv. Umran. *Intl. J. Agric. Env. Biotech.*, 8(1): 69-73
- Gurudarshan Singh and Dhaliwal, G. S., 2004, Effect of different pruning levels on fruit yield and quality of guava (*Psidium guajava* L.) cv. Sardar. *Haryana J. Hort. Sci.*, 33(1/2): 83-84.
- Hasan, M. A., Singh, B. and Sarkar, S., Jha, S., Ray, S. K., 2009, Canopy management of unproductive mango (*Mangifera indica* L.) Orchards. *Acta Hort.*, 8(2): 339-346.
- Hiremath, S., Athani, S. I., Das, K. K., Choudhury, P. R., Pujar, D., Shirol, A. M. and Gopali, J. B., 2017, Evaluation of physical characters of fruit, yield and cost economics under different crop regulation practices in guava (*Psidium guajava* L.) variety Sardar. *Intl. J. Chemical Studies.*, 5(6): 289-293.
- Hunter, J. J. and Visser, J. H., 1988, Distribution of ¹⁴Cphotosynthate in the shoot of *Vitis vinifera* L. cv. Cabernet Sauvignon. II. The effect of partial defoliation. *South African J. Enol. Vitic.*, 9: 10-15
- Islam, M. M., Bhuyan, M. A. J., Biswas, M. and Islam, M. S., 1992, Fruit size, yield and quality of guava cv. Kazi Piara as affected by fruit thinning. *South Indian Hortl.*, 40(2): 71-73.
- Jackson, J. E., 1980, Light interception and utilization of orchard system. *Horticulture Review*, 2: 208-267.
- Jadhav, B. J., Mahurkar, V. K. and Kale, V. S., 2002, Effect of time and severity of pruning on growth and yield of guava (*Psidium guajava* L.) cv. Sardar. *Orissa J. Hort.*, 30(2): 83-86.

- Jannoyer, M., 2009, Young flush thinning in mango (cv. Cogshall) controls canopy density and production. *Acta Hort.*, 820: 395-402.
- Jogaiah, S., Dasharath, P. O., Amruta, N. V., Smita, R. M., Ajay Kumar, S. and Ramhari, G. S., 2013, Influence of canopy management practices on fruit composition of wine grape cultivars grown in semi-arid tropical region of India. *African J. Agric. Res.*, 8(26): 3462-3472.
- Jozsef Racsco, 2006, Crop load, fruit thinning and their effects on fruit quality of Apple (*Malus domestica* Borkh.). *J. Agric. sci.*, Debrecen, 24.
- Khan, A. S., Khan, M. R. G., Malik, A. U., Saleem, B. A., Rajwana, I. A. and Ahmad, I., 2011, Influence of defoliation and deblossoming on the vegetative and reproductive growth of guava (*Psidium guajava* l.) cv. 'gola. *Pakistan J. Bot.*, 43(6): 2891-2896.
- Killadi, B., Singh, M. D., Singh, B. P. and Singh, R. A., 2007, Shelf life evaluation of guava (*Psidium guajava* L.) cultivars. *Acta Hort.*, 735: 603-607.
- Koblet, W., 1975, Wanderung von assimilaten uas verschiedenen rebenblättern während der reifephase der trauben. *Wein-Wiss*, 30: 241-249.
- Kohli, K., Kumar, R., Kumar, A. and Dubey, M. C., 2017, Effect of pruning height and planting distance on growth and yield of guava (*Psidium guajava* L.) cv. Pant Prabhat. *Intl. quarterly J. life sci.*, 12(1): 395-398.
- Kozlowski, T. T. and Pallardy, S. G., 1997, Physiology of woody trees. 2nd ed. Academic Press, San Diego, CA.
- Kumar, H., Katiyar, P. N., Singh, A. K. and Rajkumar, B. V., 2014, Effect of different pruning severity on growth and yield of ber (*Zizyphus mauritiana* Lamk), cv. Banarsi Karaka. *Int. J. Curr. Microbiol. App. Sci.*, 3(5): 935-940.
- Kumar, R., Ganesh, S., Chithiraichelvan, R., Upreti, K. K. and Sulladmath, V. V., 2014, Effect of spacing and pruning on growth, yield and quality of cv. Deanna fig (*Ficus carica* L.) *J. Hortl. Sci.*, 9(1): 31-37.
- Kumar, S., Naik, L. K. and Hugar, P. S., 2003, Evaluation of organoleptic parameters of guava fruit (Cv. L-49) Infested by tea mosquito bug, *helopeltis antonii* sign (Miridae : Hemiptera). *Karnataka J. Agric. Sci.*, 16(4): 562-564.

- Kumar, Y. and Rattanpal, H. S., 2010, Effect of pruning in guava planted at different spacing's under Punjab conditions. *Indian J. Hort.*, 6(7): 115-119
- Kundu, S. S., Pareek, P. and Gupta, A. K., 1994, Effect of time and severity of pruning on growth, flowering and fruiting in ber (*Ziziphus mauritiana* Lamk.) cv. Umran. *Annals of Arid Zone*, 33(1): 49-52.
- Kundu, S., 2007, Effect of high density planting on growth, flowering and fruiting of guava (*Psidium guajava* L.). *Acta Hort.*, 735: 267-270.
- Kurubar, A. R., 2007, Studies on integrated nutrient and post harvest management of fig (*Ficus carica* L.). *Ph. D. Thesis*, Uni. Agric. Sci., Dharwad.
- Lakpathi, G., Rajkumar, M. and Chandrashekhar, R., 2013, Effect of pruning intensities and fruit load on growth, yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda under high density planting. *Intl. J. current research.*, 5(12): 4083-4090.
- Lakshmi, M. L., Venkata Ramana, K. T., Sivarama Krishna, V. N. P., Yuvaraj, K. M., Naga Lakshmi, T., Sarada, G., Gouri Sankar, T., Gopi, V. and Gopal. K., 2014, Effect of growth regulators and chemicals on fruit yield and quality of hasta bahar flowering in acid lime (*Citrus aurantifolia* Swingle) cv. Balaji. *J. Agric and Allied Sci.*, 3(3): 11-13.
- Lal, S., Tiwari, J. P. and Mahajan, A. R., 2007, Studies on planting systems in guava (*Psidium guajava* L.) cv. Sardar. *Acta Hort.*, 735: 263-266.
- Mahadevan, A., Kumar, S., Swaminathan, V., Gurusamy, A. and Sivakumar, T., 2017, Effect of crop regulation and fertigation on quality characters of guava (*Psidium guajava*) cv. Sardar. *Int. J. Curr. Microbiol. App. Sci.*, 6(11): 2137-2141.
- Mahesh, P., Shant, L., Pankaj, N. and Prabhakar, J., 2017, Response of high density spacing on physico-chemical quality and yield of guava (*Psidium guajava* l.) cv. Pant Prabhat. *Intl. J. Agric. Sci.*, 9(9): 3962-3965.
- Meena, K. R., Maji, S., Kumar, S. and Verma, S., 2016, Influence of shoot pruning and crop regulation and improving fruit yield of guava. *Intl, quarterly J. life sci.*, 11(2): 1355-1359.

- Mehta, S. K., Singh, K. K., Jat, K. D. and Rana, D. K., 2016, Comparative studies of physico-chemical characteristics of various cultivars of guava (*Psidium guajava* L.) under sub tropical valley condition of garhwal himalaya (uttarakhand), India. *Plant Archives*, 16(1): 361-364.
- Mehta, S., Singh, S. K., Das, B., Jana, B. R. and Mali, S., 2012, Effect of pruning on guava cv. Sardar under ultra high density orcharding system. *VEGETOS.*, 25(2): 192-19.
- Mitra, S. K., Gurung, M. R. and Pathak, P. K., 2008, Guava production and improvement in India: An overview. *Acta Hort.*, 787: 59-65.
- Mizutani, F., 2011, Summer pruning to maintain slender spindle bush type of peach trees grafted on vigorous rootstocks. *Adv. Hort. Sci.*, 25(3): 179-186.
- Murali, K., Prasanna kumar, P. and Aneesa Rani, M. S., 2015, Effect of tertiary shoot pruning and foliar spray of nutrients on flowering and yield of cashew (*Anacardium occidentale* L.) under high density planting system. *Intl quarterly J. life sci.*, 10(1):411-415.
- Mwale, S. S., Azam-Ali, S. S. and Massawe, F. J., 2007, Growth and development of bambara groundnut in response to soil moisture: 1. Dry matter and yield. *Eur. J. Agron.*, 26: 345-353.
- Nelson, B., 1944, A photometric adaptation of the somogyi method for the determination of glucose. *J. Biol. Chem.*, 153: 375-380.
- Nikumbhe, P. H., Musmade, A. M., Mali, D. S. and Patil, R. S., 2017, Impact of pruning time on shoot initiation, shoot sprouting, fruit yield and fruit fly incidence in guava. *Int. J. Pure App. Biosci.*, 5(2): 513-518.
- Pal, M., Lal, S., Kumar, R., and Mishra, D. S., 2015, Effect of planting densities on fruit yield and chemical quality of guava (*Psidium guajava* L.) cv. Pant Prabhat. *HortFlora Research Spectrum*, 4(4): 320-323.
- Pal, V., Chandra, N., Kumar, A. and Kumar, M., 2016, Response of pruning in canopy management & high density planting in guava orchard under western Uttar Pradesh condition. *South Asian J. Food Technol. Environ.*, 2(3&4): 458-464.

- Pankaj, N., Shant, L., Dimri, D. C. and Indu, A., 2016, Shoot pruning severity in high density of guava. *Int. J. Agric. Sci.*, 8(52): 2427-2431.
- Panse, V. G., and Sukhatme, P. V., 1985, Statistical method of agricultural workers, I. C. A. R., New Delhi.
- Patel, K. M., Patel, H. C., Patel, K. A., Chauhan, V. B. and Patel, J. S., 2012, Effect of different planting distance on growth and yield of Aonla cv. GUJARAT AONLA-1. *Asian J. Hort.*, 7(2): 359-361.
- Pawar, S. K., Desai, U. T. and Choudhari, S. M., 1994, Effect of pruning and thinning on growth, yield and quality of pomegranate. *Annual of Arid Zone*, 33(1): 45-47.
- Pilania, S., Shukla, A. K., Mahaver, L. N., Sharma, R. and H. L., 2010, Standardization of pruning intensity and integrated nutrient management in meadow orcharding of guava. *Indian J. Agric. Sci.*, 80(5): 673- 678.
- Prabhakar, J., Shant, L., Pankaj. N. and Mahesh, P., 2016, Effect of plant spacing and pruning intensity on flowering, fruiting, and yield of guava (*Psidium guajava* L.) cv. Pant Prabhat. *Intl. J. Agric. Sci.*, 8(7): 1064-1068.
- Pratibha and Shanta Lal, 2012, Effect of shoot pruning and different planting system on vegetative growth, yield and quality of guava cv. Sardar. *The Asian J. Hort.*, 7(1): 65-71.
- Rajendra, P, S. and Ram Kumar, 1980, Pruning young apple trees. *Indian Horticulture*, 7-10.
- Ram, S., Singh, C. P. and Shukla, P., 2001, Effect of different planting densities on growth and yield of mango. *Indian J. Hor.*, 58(3): 191-195.
- Ranganna, S., 1979, "Manual of analysis of fruit and vegetable products". Tata McGran Hill Pub. Com. Ltd. New Delhi, pp.872.
- Rani, A., Misra, K. K., Rai, R. and Singh, O., 2018, Effect of shoot pruning and paclobutrazol on vegetative growth, flowering and yield of lemon (*Citrus limon* Burm.) cv. Pant Lemon-1. *J. Pharmacognosy and Phytochemistry.*, 7(1): 2588-2592.

- Ravishankar, H., Shivnanda, T. N. and Purohit, A. G., 2008, Effect of planting density and growth parameters on fruit yield in guava (*Psidium guajava* L.) variety Allahabad Safeda cultivated under mild tropical conditions of Coorg. *J. Hort. Sci.*, 3(2): 123-126.
- Rodrigues da Silva, M. J., Tecchio, M. A., Domiciano, S., Leonel, S., Balestrero, R. I., 2016, Phenology, yield and fruit quality of 'Paluma' guava tree at different pruning times. *Ciência e Agrotecnologia.*, 40(3): 317-325
- Sah, H., Lal, S. and Negi, S. S., 2017, Effect of pruning on growth, flowering and yield in high density planting of guava. *Int. J. Pure App. Biosci.*, 5(1): 285-292.
- Sahoo, A. K, Tarai, R. K, Dash, D. K, Shinde, G. S. and Bhusan, L. P., 2017, Effect of different level of pruning on growth, yield and fruit quality of sapota cv. Cricket ball under coastal zone of Odisha. *Int. J. Chemical Studies.*, 5(6): 2157-2160.
- Said, M., Ali, S. S. M., 1989, Pruning requirements of peach trees, variety-6- *A. Agric. Pak.*, 10: 65-72
- Saini, H., Baloda, S. and Vijay, 2016, Impact of heading back and pinching on vegetative and reproductive parameters of guava (*Psidium guajava* L.) under high density plantation. *J. Krishi Vigyan.*, 4(2): 47-53.
- Satya Prakash, Virendra Kumar, Saroj, P. L. and Sirohi, S. C., 2012, Response of yield and quality of winter guava to severity of summer pruning. *Indian J. Hort.*, 69(2): 173-176.
- Shaban, A. E. A. and Haseeb, G. M. M., 2009, Effect of pruning severity and spraying some chemical substances on growth and fruiting of guava trees. *American-Eurasian J. Agric. & Environ. Sci.*, 5(6): 825-831.
- Shaikh, M. K. and Hulamani, N. C., 1994, Effect of pruning on yield and chemical properties in Navalur guava selections. *Karnataka J. Agric. Sci.*, 7(4): 473-475.
- Shanmugasundaramm, T. and Balakrishnamurthy, G., 2017, Exploitation of plant growth substances for improving the yield and quality of pomegranate under ultra high density planting. *Int. J. Curr. Microbiol. App. Sci.*, 6(3): 102-109.

- Shanmugavelu, K. G. and Selvarajan, M., 1985, Studies on the effects of pruning on certain varieties of mango. Paper presented at the "Second International Symposium" on mango held at Bangalore, May, 20-24, p 37.
- Sharma, R. R. and Room Singh, 2006, Pruning intensity modifies canopy microclimate, and influences sex ratio, malformation incidence and development of fruited panicles in "Amrapali" mango (*Mangifera indica* L.). *Scientia Horticulture*, 109: 118-122.
- Sheikh, M. K. and Rao, M. M., 2002, Effect of pruning and fruit load on yield and quality in pomegranate (*Punica granatum* L.) var. Ganesh. *Karnataka J. Agric. Sci.*, 15(3): 549-555.
- Shiva, B., Nagaraja, A., Srivastava, M. and Goswami, A. K., 2017, Genotypic variability in photosynthetic performance and gas exchange indexes of guava cultivars. *Intl. J. Agric. Sci.*, 9(43): 4689-4692.
- Shukla, A. N., Rathore, S., Singh, H. N. and Kumar, J., 2009, Enhancing the income of orchard farmers in Uttarakhand. *Int. J. Rural Stud.*, 16: 1-4.
- Siddiqui, S., Sharma, R. K. and Gupta, O. P., 1991, Physiological and quality response of guava fruits to posture during storage. *Hort. Sci.*, 26(10): 1295-1297.
- Silva, M. R., Tecchio, M. A., Domiciano, S., Leonel, S. and Balestrero, R. I., 2016, Phenology, yield and fruit quality of 'Paluma' guava tree at different pruning times. *Ciencia e Agrotecnologia*, 40(3): 317-325.
- Singh, A. and Dhaliwal, G. S., 2007, Solar radiation interception and its effect on physical characteristics of fruits of guava cv. Sardar. *Acta Hort.*, 735: 297-302.
- Singh, A. K. and Singh, G, 2001, Influence of pruning date on fruit quality of guava (*Psidium guajava* L.). *J. Appl. Hort.*, (2): 100-102.
- Singh, G., 2008, High density and meadow orcharding of guava, CISH Lucknow, Extension Bulletin-35, 20p.
- Singh, G., 2012, Influence of pruning intensity and pruning frequency on vegetative and reproductive attributes of Sardar guava. *The Asian J. Hort.*, 7(1): 108-112.

- Singh, G., Mishra, R. and Gupta, S., 2007, Modifying existing guava tree canopies for increased production efficiency. *Acta Hort.*, 735: 243-248.
- Singh, G., Singh, A. K. and Mishra, D., 2007, High density planting in guava. *Acta Hort.*, 735: 235-241.
- Singh, G., Singh, A. K. and Rajan, S., 2001, Influence of pruning date on fruit yield of guava (*Psidium guajava* L.) under subtropics. *J. Appl. Hort.*, 3(1): 37-40.
- Singh, S. K., Malhotra, S. K., Bhargava, R., Singh, R. S. and Shukla, A. K., 2017, Morphological and physiological characterization of guava (*Psidium guajava*) under hot-arid zone of Rajasthan. *Indian J. Agric. Sci.*, 87(4): 491-495.
- Singh, S., Pratap, B., Yadav, A. and Shivam, 2017, Assess the effect of pruning and plant growth regulators on growth, flowering and fruiting of ber tree. *J. Pharmacognosy and Phytochemistry*, 6(5): 735-738.
- Singh, V. K. and Singh, G., 2007, Photosynthetic efficiency, canopy micro climate and yield of rejuvenated guava trees. *Acta Hort.*, 735: 249-257.
- Somkuwar, R. G., Ramteke, S. D., Satisha, J., Mahadev, B. and Itrotwar, P., 2014, Effect of canopy management practices during forward pruning on berry development and photosynthesis in Tas-A-Ganesh grapes. *J. Hort. Sci.*, 9(1): 18-24.
- Sousa, C. A. F., Cavalcanti, M. I. L., Vasconcelos, L. F. L., Sousa, H. U., Ribeiro, V. Q. and Silva, J. A. L., 2012, 'Tommy Atkins' mango trees subjected to high density planting in subhumid tropical climate in northeastern Brazil. *Pesq. agropec. Bras.*, 47(1): 36-43.
- Syamal, M. M. and Rajput, C. B. S., 1989, Effect of pruning on growth, fruiting and quality of ber (*Zizyphus mauritiana* Lamk.). *Indian J. Hort.*, 46(3): 364-367.
- Tabin, T., Balasubramanian, D. and Arunachalam, A., 2015, Influence of canopy pruning on orange growth and rhizome yield of intercrop ginger under Agri-Horticulture system. *Ind. J. Hill Farming.*, 28(1): 73-76.
- Tahir, F. M. and Kamran Hamid, 2002, Studies of physico-chemical changes due to fruit thinning in guava (*Psidium guajava* L.). *Online J. Biological Sci.*, 2(11): 744-745.

- Thakre, M., Lal, S., Uniyal, S., Goswami, A. K. and Prakash, P., 2016, Pruning for crop regulation in high density guava (*Psidium guajava* L.) plantation. *Spanish J. Agric. Research.*, 14(2): 2171-9292.
- Thomas, C. G., 2003, Forage crop production in the tropics (Ground legumes). Kalyani Publishers.
- Tiwari, J. P., Lal, S., 2007, Effect of NAA, flower bud thinning and pruning on crop regulation in guava (*Psidium guajava* L.) cv. Sardar. *Acta hort.*, 735: 311-314.
- Virendra, P. Naveen, C. Anant, K. and Mukesh, K., 2016, Response of pruning in canopy management & high density planting in guava orchard under western Uttar Pradesh condition. *South Asian J. Food Technol. Environ.*, 2(3&4): 458-464.
- Yadav, E. D., 1978, The effect of plant density on growth, yield, quality and production economics of Sardar guava (*Psidium guajava* L.). *M.Sc. Thesis*, MPKV, Rahuri.
- Yeshitela, T., Robbertse, P. J. and Stassen, P. J. C., 2003, The impact of panicle and shoot pruning on inflorescence and yield related developments in some mango cultivars. *J. Appl. Hort.*, 5(2): 69-75.

APPENDIX - I

Prices of inputs and outputs

Sl. No.	Particulars	Prices (Rs.)
1	Organic manures	
	a) Farmyard manure	1500 per tone
2	In organic fertilizers	
	a) Urea	6000 per tonne
	b) Di ammonium phosphate	22500 per tonne
	c) Muriate of potash	12000 per tonne
3	Plant protection chemical	
	e) Imidachloropid (1lt)	2,776 per ltr
	f) chlorophyriphos (1lt)	160 per ltr
4	Labour wages	
	a) Men labour	250 per day
5	Miscellaneous	20,000
	Out put	
6	a) Marketable guava fruits	15 per kg