

**Studies on canopy management in
high density planting of guava
(*Psidium guajava* L.)**

By
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(2014A27D)

*Dissertation submitted to the Chaudhary Charan Singh
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**DOCTOR OF PHILOSOPHY
IN
HORTICULTURE
(FRUIT SCIENCE)**



**COLLEGE OF AGRICULTURE
CCS HARYANA AGRICULTURAL UNIVERSITY
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2018

CERTIFICATE - I

This is to certify that this dissertation entitled “**Studies on canopy management in high density planting of guava (*Psidium guajava* L.)**” submitted for the degree of **Doctor of Philosophy**, in the subject of **Horticulture- Fruit Science** to the **Chaudhary Charan Singh Haryana Agricultural University, Hisar** is a bonafide research work carried out by **Ms. Anjali Tripathi (Admission No. 2014A27D)** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE – II

This is to certify that this dissertation entitled “**Studies on canopy management in high density planting of guava (*Psidium guajava* L.)**” submitted by **Ms. Anjali Tripathi (Admission No. 2014A27D)**, to the **Chaudhary Charan Singh Haryana Agricultural University, Hisar** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy**, in the subject of **Horticulture- Fruit Science** has been approved by the Student’s Advisory Committee after an oral examination on the same, in collaboration with an **External Examiner**.

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LIST OF ABBREVIATIONS

%	:	Per cent
°B	:	Degree brix
°C	:	Degree Celsius
/	:	Per
CD	:	Critical Difference
cm	:	Centimetre
cv.	:	Cultivar
<i>et al.</i>	:	et. alia (and others)
Fig.	:	Figure
kg	:	Kilogram
g	:	Gram
mg	:	Milligram
ha	:	Hectare
<i>i.e.</i>	:	That is
l	:	Litre
ml	:	Millilitre
m	:	Metre
mm	:	Millimetre
MT	:	Metric Tonnes
F _o	:	Minimal fluorescence yield in the dark adapted state
F _m	:	Maximal fluorescence yield in the dark adapted state
F _v /F _m	:	Ratio of variable to maximum fluorescence
TSS	:	Total Soluble Solids
<i>Viz.</i>	:	<i>videlicet</i> Namely
@	:	At the rate
cm ³	:	Centimetre cube
var.	:	Variety
N	:	Normality
ppm	:	Parts per million

CHAPTER-I

INTRODUCTION

Guava (*Psidium guajava* L.) is undoubtedly the most important tropical and subtropical fruit crop of the world. It belongs to the family Myrtaceae which comprises 150 species of trees and shrubs many of which have edible fruits. Guava is believed to be originated in tropical America. In India it has been cultivated since early in 17th century. It can be considered as the 'Apple of Tropics' for its high vitamin C and mineral content and also known as 'Poor Man's Fruit'. Guava fruits are used both for fresh consumption and processing.

In India, guava is fifth in terms of area after mango, citrus, banana and apple whereas, it also ranks fifth in production after banana, mango, citrus and papaya. The total area and production of guava in the country are 0.26 million hectares and 3.65 million MT respectively with productivity of 13.9 MT/ha (Anonymous, 2017). Major guava producing states are Bihar, Uttar Pradesh, Maharashtra, Karnataka, Orissa, West Bengal, Andhra Pradesh and Tamil Nadu. However, Uttar Pradesh, is by far the most important guava producing state of the country and Allahabad has the reputation of growing the best guava in the country as well as in the world.

Haryana produces about 0.185 million tonnes of guava fruits from an area of 12,030 ha with productivity of 15.43 t/ha (Anonymous, 2017). Major guava producing areas in Haryana are Mewat, Hisar, Sirsa, Fatehabad, Jind, Jhajjar, Sonipat, Karnal, Yamuna Nagar and Ambala.

Although, area and production of guava increased rapidly in last decade, yet there has been no significant increase in productivity. Therefore, to increase productivity level to its maximum potential, research work on adoption of modern, innovative and hi-tech methods has to be carried out. The major focus of research should be on planting at appropriate plant density, canopy management, quality planting material and support as well as management system with appropriate inputs.

High density planting (HDP) has been attempted in various tropical, sub-tropical and temperate fruit crops. HDP results in increase of productivity, yearly yield and higher income per unit area. As tree density increases, inter- plant competition is quite obvious which is likely to be reflected in the pattern of plant growth, yield potential of the tree and fruit quality. Dense orchards frequently become uneconomical comparatively earlier than the standard orchards because the tree size although reduced by competition, can not be controlled

sufficiently to prevent light competition, internal shading and barrenness to overcome this problem. Pruning is done in guava to manage the tree canopy under high density planting.

Guava bears on current season's growth and flowers appear in the axils of new leaves, therefore, it responds well to pruning. Pruning of guava is one of the most important practices that influences the vigour, productivity and quality of the fruits under high density planting. Hence, there is over riding need to improve the existing planting system and to manipulate tree growth using canopy management tree growth patterns, tree shape and maintaining high fruit production of desired size and quality. Fruit thinning in the early stages of fruit growth increases size of remaining fruits, reduces trunk breakage and promotes regular bearing. Fruit set, fruit size and quality also now improved by pruning. The pruning levels in guava under high density conditions have achieved a great importance.

Pruning is usually practised in the summer (April–May) before flower initiation. Studies have reported that the time and level of pruning influence growth, flowering, quality and yield of guava (Chandra and Govind, 1995). The rainy season crop gives maximum production of guava, however the fruits are of poor quality and severely infected by fruit fly. On the other hand winter season fruits are more nutritious and superior in quality but the yield is low. Summer pruning plays an important role in crop regulation of guava, it reduces the rainy season yield and increases the winter season yield. Kumar and Rattanpal (2010) reported that fruit weight, TSS, total sugars, vitamin C and low acidity was found best with the pruning treatment by half removal of vegetative growth at 6×4 m spacing in guava.

Guava crop is highly suitable for high density planting because pruning gives positive response in guava as it bears on current season growth. The principle objective to underlying modern planting system is to promote the light distribution within tree canopy through optimized total light interception by reducing individual tree size and arrangement (Tustin *et al.*, 1989). Pruning is the practice which performed in an appropriate manner to provide the plant such a shape and size so as to yield the desired crops. So, the pruning approach should be aimed to regulate the tree size without loss of fruit quality and yield per unit area.

Pruning is necessary for building strong frame work of the trees in early years and for maintaining vigour, yield, productivity and quality of fruits in the later years. Therefore, HDP has consistently gained popularity and acreage particularly with small land holdings during the past few decades.

Canopy in fruit tree refers to its physical composition comprising of the stem, branches, shoots and leaves. Canopy management of fruit trees deals with the development and maintenance of their structure in relation to the size and shape for maximum productivity and quality. The basic concept in canopy management of a perennial tree is to make the best use of land and the climatic factors for increased productivity in a tree dimensional approach.

Tree vigour, light, temperature and humidity play a vital role in the production and quality of fruits. Therefore, the crux of the canopy management lies in the fact, as to how best we manipulate the tree vigour and use the available sunlight and temperature to increase the productivity and quality to minimize the adverse effect of weather parameters. Light interception is a key parameter for the production of biomass and its effect on fruit sugar and acid content, fruit firmness and colour. Singh (2011) observed that guava at closer spacing showed significant effect on PAR (Photosynthetically Active Radiation) and fruit TSS.

Canopy architecture can be manipulated through various means like training, pruning, rootstocks, PGR's, moisture stress and nutrition. High density planting, light interception and other microclimatic conditions (canopy temperature and relative humidity) are important aspects which directly or indirectly affects the vegetative growth, yield and quality of fruits.

Keeping in view the requirement of pruning and microclimatic conditions under high density planting, the present research problem was formulated with the following objectives:

- To study the microclimate of tree canopy under different pruning treatments and plant densities
- To study the pattern of growth and productivity of the tree canopy under high density planting

CHAPTER-II

REVIEW OF LITERATURE

Canopy management of fruit trees deals with the development and maintenance of their structure in relation to the size and shape for maximum productivity and quality. Canopy management aims at optimization of light interception and maximizing the production of assimilates and its conversion into fruits of acceptable quality. The relevant literature regarding the canopy management by pruning and planting densities of fruit trees and its effect on vegetative growth, fruit yield and quality is reviewed under the following heads:

The published literature that has been used either for planning and execution of the experiment or for the interpretation of the results is reviewed here in under appropriate subheads.

2.1 Effect of pruning and plant densities on the canopy microclimatic factors of fruit crops

2.1.1 Solar radiation interception, Canopy temperature and Relative humidity

Morgon *et al.* (1984) studied the effect of summer pruning on guava and observed that photosynthetic photon flux density (PPFD) penetration was increased in summer pruned trees. Higher tree density leads to increased light interception through greater leaf area and more even distribution of light in apple (Palmer *et al.*, 1992). Singh *et al.* (2005) reported in guava that solar radiation interception is less at widest spacing 6×5 m in guava which may be due to less dense foliage per unit exposed area to solar radiations. Singh and Dhaliwal (2007) observed in guava that radiation interception and canopy temperature were increased with increasing the planting distance. While relative humidity was found maximum with closet spacing. Singh *et al.* (2007) conducted an experiment on guava and found that better light penetration and canopy temperature were observed in the trees planted at 6×6 and 3×6 m than the other distances (3×3 and 3×1.5m) at NS/EW canopy edge.

Singh and Singh (2007) reported that canopy temperature was recorded maximum at 2.0 m pruning height and minimum in unpruned guava trees. They further reported that an increase in photosynthesis and photosynthetically active radiation with increase in pruning level in guava was observed. Brar *et al.* (2009) examined in guava that with increase in plant spacing from 6x2 m to 6x4 m the interception of radiation and canopy temperature increased significantly during rainy and winter season crops and observed that more than 75% radiations were intercepted the upper 1/3rd portion of plant canopy, irrespective of plant spacing followed by 12-16% in middle and 6-9% in the lower 1/3rd parts of plant canopies and canopy temperature found maximum at widest spacing at 6 x 4 m and minimum at 6x2

m. They further reported that relative humidity increased with decreasing the plant densities, maximum (62.3%) relative humidity was noted in dense planting and minimum (53.0%) in the widest spacing. Relative humidity was slightly higher in the lower and middle canopy than in the upper 1/3rd parts of plant canopy. Singh (2011) observed that guava at closer spacing showed significant effect on PAR and fruit TSS. Pruning shows favourable influences in relation to better light penetration in mango. Brar *et al.* (2012) studied in guava and observed that wider spacing was found to be better owing to maximum absorption of solar radiation and optimum microclimate in orchard leading to better yield, higher fruiting density and yield efficiency.

Kumawat *et al.* (2014) conducted an experiment on the effect of different spacing on newly planted guava *cv. L- 49* under ultra high densities and found that maximum light interception below canopy ($356 \mu \text{ Mol/ m}^2 \text{ S}$) was recorded under 2.0x2.0 m spacing and minimum under 1.0 x 1.5 m spacing. Bhagawati *et al.* (2015) pruning found to have rejuvenating impact on aged trees due to better light interception leading to better photosynthetic rate, better nutrient and water supply with reduced canopy and better quality yields.

2.1.2 Chlorophyll fluorescence

Chlorophyll fluorescence has been studied as a helpful tool to evaluate the ripening and senescence of green tissues, being used in both green leaves and several chlorophyll-containing fruits (Born *et al.*, 2005 and Deell *et al.*, 2000). Chlorophyll fluorescence emission at room temperature is almost exclusively originated from light-excited chlorophyll *a* molecules associated with photosystem II (PSII), reflecting the primary photosynthetic reactions in the thylakoid membranes (Schreiber *et al.*, 1987). For excited chlorophyll molecules to return to the ground level (de-excited), one or more of the following mechanisms is necessary: fluorescence emission, excitation transference to neighboring molecules, photochemical reaction and/or thermal dissipation (Schreiber *et al.*, 1998). Chlorophyll fluorescence was influenced by the reductions in chlorophyll content and chlorophyllase activity in ripe and senescence fruits (Tucker *et al.*, 1993).

Smillie *et al.* (1987) reported that the decline in chlorophyll fluorescence during the ripening of banana and mango was associated with loss of chlorophyll content and chloroplast competence. Bron *et al.* (2004) conducted an experiment on guava and observed that chlorophyll fluorescence can be used to evaluate the ripening and senescence of guava fruit, with F_m being a good ripening indicator. This parameter accompanied skin color changes, improving the detection of initial ripening changes in guava fruit.

2.2 Effect of pruning and plant densities on the growth characteristics

2.2.1 Tree height

Kuar and Dhaliwal (2001) conducted an experiment to study the effects of pruning date (10, 20 and 30 April) and level (0,10, 20 and 30 cm) on the canopy height on six year old guava cv. Sardar trees with 6x6 spacing and observed that tree height increased with the increase in the severity of pruning. Singh *et al.* (2007) reported in guava that tree height reduced with increasing the plant spacings. Plant height increased with increasing the plant density (Kundu, 2007). Pratibha *et al.* (2013) reported in guava that one leaf pair pruning significantly reduced the tree height.

2.2.2 Tree spread

Singh and Bal (2002) reported in guava that maximum tree spread was found in trees spaced at 6x6 m in E-W direction. Lal and Mishra (2008) conducted an experiment in mango cv. Dashehari and observed that tree spread found maximum in un-pruned trees than pruned trees. Kumar and Rattanpal (2010) studied the effect of pruning in guava planted at different spacing under Punjab condition and revealed that the mean tree spread was found maximum (6.5m) in control trees of 6x6 m spacing and was minimum (4.8m) in pruning by removal of half the vegetative growth at spacing of 6x4 m. Pratibha *et al.* (2013) conducted an experiment to study the effect of pruning and planting system on growth flowering, fruiting and yield of guava cv. Sardar and observed that the tree spread highest in square system of planting with one leaf pair pruning during both the years.

2.2.3 Canopy volume

Kaur and Dhaliwal (2001) observed in guava that highest net increment in tree volume of 20.87 m³ over control with 30 cm pruning level. Singh and Bal (2002) reported in guava that maximum mean tree volume (58.35m³) was observed in plants at 6x5m spacing, followed by 55.23 m³ at 6x4 m spacing. Trees at closest (6x2 m) spacing had minimum (46.79 m³) tree canopy. Brar *et al.* (2012) conducted an experiment on guava and revealed that canopy volume increased with wider plant spacing

Pal *et al.* (2016) reported in guava cv. Allahabad seedless that canopy volume increased with plant spacing 3x3 m. Sah *et al.* (2017) studied on guava cv. Pant Prabhat and found that half (50%) shoot pruning in April and July have positive effect towards vegetative growth and plant volume in rainy and winter season crop.

2.2.4 Shoot length

Singh *et al.* (2001) conducted an experiment on guava and revealed that May pruning found best for increasing the length of new shootlet. Jadhav *et al.* (2002) noticed that earliest emergence of vegetative bud sprouts, shoots, number of flower per shoot and number of fruits per shoot, on severely pruned (60cm) tree of guava was significantly more than other

treatments. Jens *et al.* (2005) reported in apple that shoots length was increased with decreasing crop loads.

Mohammed *et al.* (2006) observed in guava that pruning at 60cm resulted in minimum number of days for sprouting of new shoots, maximum shoot length and higher number of leaves per shoot during rainy and winter season. The length of new shoot of guava on severely pruned shoots was found longer than moderate pruning (Shaban and Haseeb, 2009). Kumar *et al.* (2014) conducted an experiment on ber cv. Banarasi Karaka and found that maximum shoot length with 60% pruning on previous year growth. Bhagawati *et al.* (2015) conducted an experiment in guava and observed that shoot length was found maximum in severely pruned trees. Guava plants were pruned in different shoot length 15, 30, 45 and 60 cm from tip in different month April, May and June and highest new shoot length (1.83cm) was found after 15 days pruning which was shoot pruned in May at 45cm (Meena *et al.*, 2016).

2.2.5 Chlorophyll 'a' and 'b' content of leaves

Chlorophyll is an antioxidant compounds which are present and stored in chloroplast of leaf plants and mainly it is present in the green area of leaves, stem flowers and roots (Mirza *et al.*, 2013). Kamble *et al.* (2015) conducted an experiment in guava and observed that chlorophyll 'a' and chlorophyll 'b' content was found higher in younger leaves than adult leaves. Richardson (2002) revealed that the chlorophyll a and chlorophyll b are essential pigment of the photosystems. Chlorophyll a is the primary photosynthetic pigment in plants which helps to produce energy in plant (Srichaikul *et al.*, 2011).

2.2.6 Leaf area and leaf area index

Palmer *et al.* (1992) conducted an experiment on apple and study the effect of spacing and summer pruning on leaf area distribution and light interception and observed that leaf area index (LAI) varied from 1.4 for Golden Delicious at 2000 trees per hectare to 3.3 at 8333 trees per hectare. Kumawat *et al.* (2014) conducted an experiment on effect of different spacing on newly planted guava cv L- 49 under ultra high densities and found that maximum (97.16 cm²) leaf area was recorded under 2.0x2.0 spacing and minimum under 1.0x1.5 spacing and maximum (3.29) leaf area index (LAI) was found under 1.0x1.5 and minimum under 2.0x2.0 spacing. Wunsche *et al.* (2000) studied in apple to evaluated the relationship of spur vs. extension shoot leaf area and light interception of orchard productivity and observed that leaf area was significantly higher at 3-5weeks after full bloom (AFB) and spur canopy leaf area index (LAI) was found significantly and positively correlated with yield while extension leaf area index (LAI) was poorly correlated with yield.

2.3 Effect of pruning and plant densities on the flower and fruit characters of fruit crops

2.3.1 Duration of flowering

Singh *et al.* (2010) reported that pruning intensity at moderate level in high density planting of mango took lowest number of days to 50% of flowering, had highest number of panicles per branch and longest blooming period.

2.3.2 Flower bud density

Pruning from April through June increased the flowering percentage of guava trees as compared to pruning in February and March pruning (Singh *et al.*, 2001). Jadhav *et al.*, (2002) studied in guava and observed that maximum flower per shoot were found during winter season with 60 cm pruning treatment. Mohammed *et al.* (2006) revealed in guava 60 cm pruning gave maximum number of flowers and fruits per shoot during winter season. Pilia *et al.* (2010) reported in guava that 25 per cent pruning of previous season growth gave maximum number of flowers/ shoot followed by 50 per cent pruning and minimum in control. Pruning three times a year resulted in maximum (20.13) number of flowers per plant. Whereas pruning to 80% of canopy in October resulted in minimum (7.72) number of flowers per plant during winter.

Joshi *et al.* (2016) studied in guava and using different treatments that two plant spacing and three pruning intensities i.e., one fourth, half and three fourth shoot pruning with un-pruned treated as control. The highest number of flower bud emergence per plant was recorded with treatment combination 2.0X2.0 m plant spacing and 3/4th shoot pruning for winter season crop during both the year and three fourth shoot pruning proved significantly superior over other pruning treatments for emergence of new shoots and number of flower buds per plant for winter season crop.

2.3.3

Fruit set (%), fruit drop (%) and fruit retention (%)

Three year old trees of guava cv. Sardar were pruned at 5 intensity levels (Controls, and 25, 50 and 100%), and on 6 dates & from 20 February to 30 May 1993 at 20 day intervals). Percent fruit set and fruit retention increased with increasing pruning intensity, while pruning date had no effect on these parameters. Maximum fruit number was at 50 per cent pruning intensity, while the minimum was at 100% (Dhaliwal *et al.*, 2000).

Dalal *et al.* (2004) studied the pruning intensity in guava cv. L- 49 trees. Treatments comprised 4 pruning intensities taking 2.0, 3.0 and 4.5 cm thick shoots from the tip and revealed that the significantly higher fruit set (88.53%) was observed with heavy pruning compared to other treatments. Fruit set increased with increasing pruning intensity. Brar *et al.*

(2007) conducted an experiment on guava and observed that the increasing the pruning intensity increased the fruit set and decreased fruit drop per cent.

Pratibha *et al.*, (2013) studied in guava that maximum (60.4%) fruit set was found in un-pruned guava plant under square system of planting and lowest (11.6%) fruit set was observed in combination of one leaf pair pruning and double hedge row system of planting during rainy season. While in winter season the maximum (65.6%) fruit set was found in treatment combination of one leaf pair pruning and square system of planting and minimum (18.5%) in un-pruned plants under double hedge row system of planting during both years.

2.4 Effect of pruning and plant densities on the fruit yield of fruit crops.

2.4.3 Number of fruits/ tree

Sarkar and Ghosh (2005) conducted an experiment on the effect of different intensity of pruning and bending of shoots to induce off season flowering was studied in 6 years old plants of guava cv. L- 49 at Mondouri , West Bengal. Five treatment were evaluated: bending of shoots: 1 leaf pair pinching from tip; 10 cm pruning from tip; 20 cm pruning from tip; and control plants. Among the treatments, bending of shoots resulted in the earlier emergence of shoot lets and flower buds, and increased the number of new shootlets per branch, number of flowers and fruits per shootlet bending of shoots (autumn) gave the highest number of fruits (196.50) and yield (42.60 kg) per plant, followed by 20 cm pruning from tip producing 87.75 fruits and 15.33 kg of fruits per plant. The control plant produced the lowest yield of 31.25 fruits per plant (4.67 kg/plant). Sharma and Singh (2006) studied in mango and observed that highest (80.3) number of fruited panicles appeared in moderately pruned mango trees and lowest (24.6) in unpruned trees. Singh *et al.* (2007) conducted an experiment in guava and observed that maximum number of fruits per tree was found with moderately pruned trees. Brar *et al.* (2007) revealed in guava that number of fruits per tree increased with 15cm light pruning intensity.

2.4.4 Fruit weight

The increase in number and area of leaves increases the amount of photosynthates that cause a significant increase in size and weight of fruit in the winter season (Singh *et al.*, 2001). Sheikh and Rao (2002) conducted an experiment on pomegranate and found that the highest fruit diameter and fruit weight were noticed with severe pruning and 30 fruit load against mild pruning and 50 fruits load. Singh and Dhaliwal (2004) revealed in guava that pruning at 30 cm produced the maximum fruit weight and fruit size and also recorded that increase in length and breadth may be attributed to the reduction of fruit loads, which is take more nutrients to the remaining fruits, thereby increasing the fruit size.

Singh and Bal (2006) conducted an experiment on guava and observed that fruit weight was maximum in 6x3 m and minimum in 6x4 and 6x2 m spacing. Under high density

planting conditions, fruit weight of mango was significantly influenced by pruning and was highest in the lightly pruned trees (Singh *et al.*, 2010).

2.4.3 Fruit size

Singh and Dhaliwal (2004) conducted an experiment on guava and observed that maximum (6.8 cm) fruit length was found with 30cm pruning level as compared to 10 and 20cm pruning levels. Mohammed *et al.* (2006) reported in guava that fruit size was found maximum in 60 cm pruning treatment during rainy season and in 30cm pruning treatment during winter season. Brar *et al.* (2007) conducted an experiment on guava and found that length and breadth of fruits obtained from pruned trees were significantly higher than the fruits from unpruned trees. Sdoodee *et al.* (2008) reported that moderate crop load of mangosteen tree provided high yield with high percentage of large fruits.

Pratap *et al.* (2009) revealed in mango that the size of fruits improved with the severity of pruning treatment under high density planting. Singh *et al.* (2012) conducted a field study to examine the effect of low heading back pear plant photosynthesis yield and fruit quality and observed that fruit size enlarged linearly with the intensity of pruning.

2.4.4 Yield per tree and yield per hectare

A light pruning is considered necessary to encourage new shoots after the harvest. Shoot pruning is helpful in reducing the tree size and improving the fruit quality and provide opportunity to increase the number of tree per unit area (Lal *et al.*, 2000). Singh (2008) noticed that the production of guava in high density planting (1.5x3.0 m) was 26 t/ha in the third year. The yield increased up to 47 t/ha in the fifth and 55 t/ha in the seventh year of growth. In the density of 6 x 6 m, the yield was 6 t/ha in the third year.

Sahar and Hameed (2014) conducted an experiment and observed that number of fruits per tree, yield per tree and fruit weight better with apical 10 cm of shoot pruning in May. Adhikari and Kandel (2015) reported in guava that 20 cm shoot pruning in early May was the most effective management to reduce yield in the rainy season and enhance yield in the winter season. Prakash *et al.* (2012) revealed in guava that increase in summer pruning severity, yield of winter season fruits was improved significantly up to 33% pruning intensity. On the other hand, rainy season crop showed almost a reverse trend and fruit yield was inversely related to severity of pruning. The maximum yield in rainy season was recorded with un-pruned shoot trees, while fruit yield was significantly reduced in trees receiving severe pruning.

Dubey *et al.* (2002) studied in guava and found that highest yield of quality fruit during winter season with moderately shoot pruned in May, while later recorded lowest fruit yield in rainy season and highest yield in winter season with severely pruned trees in summer. Kundu (2007) studied that the effect of different plant densities, viz., 278(6x6 m), 625(4x4 m), 1111(3x3 m) and 1600 plants/ha (2.5x2.5 m) in guav cv. Lucknow-49 and revealed that

increase in plant density from 278 to 1600/ha has decreased the yield from 36.8 kg to 27.9 kg /plant, reduced the fruit weight from 135.4 gm to 125.7 gm, but increased the yield /ha from 102.4 to 446.5 q/ha.

Kumar and Rattanpal (2010) conducted an experiment on guava and found that fruit yield was the highest in control trees at 6x5 m spacing in rainy season , while in winter season maximum fruit yield per tree was obtained in pruning treatment by removal of 1/3rd vegetative growth at 6x5m spacing. However total fruit yield and yield t/ha of both rainy and winter season was maximum in pruning treatment by ½ removal of vegetative growth 6x4 m spacing. Dalvi *et al.* (2010) recorded highest yield (6.4 MT/ha) with the spacing of 5x5 m without reduction in fruit size in 10 year old plants of mango cv. Alphanso compared to the mean yield of 1.12 MT/ha in 10x10 m normal spacing. High density plantation helped to get significantly higher yield per unit area compared to the normal spacing, without affecting size and quality of mango fruits.

2.4.5 Fruiting density and yield efficiency

Singh (2006) revealed in guava cv. Sardar that with closest (6x2 m) and wider spacings (6x4 m and 6x5 m) the yield efficiency was more as compared to 6x3 m spacing in both rainy and winter season.

2.5 Effect of pruning and plant densities on the quality parameter of fruit crops

The fruit of rainy season crop are rough, insipid, poor in quality due to high temperature, rainfall and humidity which leads attacked by several insect-pest and pathogens so that, rainy season crop should be avoided. On the other hand, winter season crop is superior in quality, free from diseases and fetches high price as compared to rainy season crop (Prakash *et al.*, 2012)

2.5.3 Fruit firmness

Jens *et al.* (2005) conducted an experiment on apple and observed that fruit from light-cropping trees displayed advanced maturity and also found that fruit from light-cropping trees were larger, firmer and sweeter than fruits harvested from high cropping trees.

2.5.4 Total soluble solids

Singh and Bal (2002) conducted an experiment in guava and observed that maximum TSS content was found in fruits harvested from widest spacing. Bending of shoots treatments showed the highest (10.60 °B) TSS content of fruits followed by 20cm pruning (10.36 °B) and minimum (9.39 °B) in control (Sarkar *et al.*, 2005). Kumar and Rattanpal (2010) conducted an experiment on guava and observed that maximum (10.40% and 11.05%) TSS was found in fruits produced by trees subjected to removal of half vegetative growth at 6x4 m spacing and it was significantly higher than all other pruning treatments and minimum (9.30% and 9.81%) in control trees at closer spacing (6x4 m) in rainy and winter seasons.

Sahar and Hameed (2014) reported in guava that pruning at 10cm gave the highest significant value of TSS in both seasons. Regarding to date pruning at May and June gave

highest significant value in first season. In second season pruning at 10cm recorded highest significant value. Adhikari and Kandel (2015) observed in guava that TSS (%) of fruits increased with the increasing level of pruning in both seasons irrespective of timing of pruning. Bhagawati *et al.* (2015) reported in guava that TSS of fruits was found to increase with enhanced pruning severity and lowest in case of no pruning treatment. Nautiyal *et al.* (2016) found that plants at wider spacing was produced fruits with maximum TSS content as compared to fruits from narrow spacing (2.0x1.0 m). Suresh and Shakila (2017) conducted an experiment on guava and observed that 30 cm of apical shoots during mid March proved to be the best in increasing the TSS of fruits followed by 20 cm level of pruning during mid March.

2.5.5 Total sugars

Dubey *et al.* (2001) reported in guava that maximum (7.09% and 10.4%) total sugars were found at 100 per cent pruning intensity and minimum (6.14% and 9.19%) in control trees during rainy and winter season. Deblossoming of summer season flowers with pruning of current season shoots and urea spray significantly increased total sugars in guava (Sahay and Singh, 2001). Kumar and Rattanpal (2010) conducted an experiment on guava and revealed that maximum (7.9% and 9.4%) total sugars found with pruning by removal of half vegetative growth and minimum (7.1% and 7.4%) in control trees. Total sugars was found maximum in fruits harvested from trees spaced at 6x6 m than the fruits harvested from 6x4 m and 6x5 m spacing (Singh and Dhaliwal, 2004).

Sahar and Hameed (2014) conducted an experiment on guava and observed that pruning at 10cm gave the highest significant value of total sugars in both the seasons. Regarding to date pruning at May and June gave highest significant value of total sugars in both the seasons. Pruning in peach enhanced the total sugars content in fruits while, reduced firmness and acidity (Abeer and Mohsen, 2010). Bhagawati *et al.* (2015) reported in guava that total sugars in fruits were increased with increasing the pruning severity. Jayswal *et al.* (2017) reported in guava that highest total sugars (8.07%) were found with pruning at 40cm and minimum was observed in un-pruned trees. Suresh and Shakila (2017) conducted an experiment in guava and observed that 30 cm pruning of apical shoots during mid March proved to be the best in increasing the total sugar content of fruits followed by 20 cm level of pruning during.

2.5.6 Ascorbic acid

Dhaliwal and Kaur (2003) studied the effect of severity of pruning on the fruit quality of guava with pruning intensities (0, 10, 20 or 30 cm) and found that the highest (202.3 mg/100g of pulp) mean ascorbic acid content was registered with 30 cm pruning level.

Singh and Dhaliwal (2004) conducted an experiment in guava and observed that the highest ascorbic acid content was found with severely pruned tree over control in winter and rainy season; they further reported that ascorbic acid content increased with increasing plant spacing.

Kumar and Rattanpal (2010) studied in guava and observed that vitamin C content was found best with the pruning treatment by 1/2 removal of vegetative growth at 6×4 spacing. Singh (2011) conducted an experiment on guava and found that pruning treatment increased the vitamin C of harvested fruits from different planting densities. Prakash *et al.* (2012) reported in guava that moderately pruned trees gave highest ascorbic acid content of fruits in winter season. Jayswal *et al.* (2017) studied in guava and observed that maximum (241.0mg/100g) ascorbic acid was found with 40cm shoot pruning and minimum in un-pruned plants. Pruning of 30 cm apical shoots of guava during mid March proved to be the best in increasing the ascorbic acid content of fruits followed by 20 cm level of pruning during mid March (Suresh and Shakila (2017)

2.5.7 Titratable acidity

Sahay and Singh (2001) reported in guava that lowest acidity (0.24% in rainy and 0.36 in winter season) was measured from the fruits subjected to 50 per cent of pruning during both the seasons, whereas maximum acid (0.36 and 0.49%) content was recorded in fruits from control tree in both rainy and winter season crops. Dubey *et al.* (2001) conducted an experiment on guava and observed that highest (0.37% and 0.53%) acid content in control fruit trees and lowest (0.33% and 0.50%) in 75 per cent pruning level of May during rainy and winter season. Tahir and Kamran (2002) reported in guava that fruit acidity was decreased in completely thinned plants.

Dhaliwal (2004) studied in guava and found that all the pruning intensities could not alter the acid content of fruits during rainy season, while 10cm pruning level eclipsed the 20cm and 30cm pruning levels acidity was observed significantly higher (0.35%) during winter season. Acidity of fruits was decreased with increasing the pruning intensities (Bhagawati *et al.*, 2015). Suresh and Shakila (2017) revealed that in guava 30 cm shoot pruning during mid March significantly decreased the acid content of fruits.

2.6 Estimation of leaf NPK

Shikhamany *et al.* (1986) reported that about 2.59 times more fruit yield was obtained during rainy season due to better vegetation vigour which was reflected in high removal of nutrients (N, P and K). Reddy *et al.* (2001) conducted an experiment on mango and observed that high yielding trees had higher leaf content than the low yielding trees and found fruit yield was positively correlated with leaf N before and during flowering, with leaf P after harvest and with leaf K before flowering.

Adhikari (2009) conducted an experiment on guava and observed that highest NPK content of leaves found with increasing pruning severity in guava. Mishra (2014) revealed in guava that tree removes high amount of N, P and K from the soil and produce higher yield year after year. Singh *et al.* (2017) conducted an experiment on guava and observed that highest N, P and K content of leaves observed on the plants which was 60% shoot pruned. A light pruning is considered necessary to encourage new shoots after the harvest.

The present investigations entitled, **Studies on canopy management in high density planting of guava (*Psidium guajava* L.)** was conducted in experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar during rainy and winter season in the year 2016-2017. The details of experimental site, experimental materials used and the methodologies/techniques followed during the course of investigation are given below.

3.1 EXPERIMENTAL SITE

3.1.1 Location

The experiment conducted at the field orchard of CCS Haryana Agricultural University, Hisar, situated at latitude of 29⁰10'N, longitude of 75⁰46'E and altitude of 215.2 m above sea level in semi-tropical region of western zone of India.

3.1.2 Weather and climate

Hisar has a typical semi-arid climate with hot and dry summer and extremely cold winter. The mean monthly maximum and minimum temperature show a wide range of fluctuations both during summer and winter months. A maximum temperature of around 47°C during summer month May to June and temperature as low as freezing point accompanied by frost on occasions in winter months of December and January are common in this region. The total rainfall as well as its distribution in the region is subjected to large variations. About 80 per cent of the annual rainfall (about 450 mm) is received during July to September. A few showers also occur during the months from December to February from the western disturbances. The rainfall is highly erratic with 20-30 per cent annual and 30-50 per cent seasonal variation.

3.1.3 Experimental details

The experiment was laid out in randomized block design (RBD) allocating two levels of pruning and nine different spacing with three replications, comprising 18 treatment combinations. Trees for the study were uniformly grown seven year old, spaced at a distance of 6×2 m, 6×3 m, 6×4 m, 6×5 m, 5×2 m, 5×3 m, 5×4 m, 5×5 m and 6×6 m. They were kept under uniform condition of orchard management during the study period with all agronomic practices carried out as per package and practices.



Plate1. Experimental Orchard of guava cv. Hisar Safeda

Cultivar - Hisar Safeda

Pruning levels - 2 viz

(a) No pruning

(b) 50% pruning of last season growth

Time of pruning - April

Spacing - 9

Treatments:

T₁: 6.0 m × 2.0 m (No pruning)

T₂: 6.0 m × 2.0 m (50% pruning of last season growth)

T₃: 6.0 m × 3.0 m (No pruning)

T₄: 6.0 m × 3.0 m (50% pruning of last season growth)

T₅: 6.0 m × 4.0 m (No pruning)

T₆: 6.0 m × 4.0 m (50% pruning of last season growth)

T₇: 6.0 m × 5.0 m (No pruning)

T₈: 6.0 m × 5.0 m (50% pruning of last season growth)

T₉: 5.0 m × 2.0 m (No pruning)

T₁₀: 5.0 m × 2.0 m (50% pruning of last season growth)

T₁₁: 5.0 m × 3.0 m (No pruning)

T₁₂: 5.0 m × 3.0 m (50% pruning of last season growth)

T₁₃: 5.0 m × 4.0 m (No pruning)

T₁₄: 5.0 m × 4.0 m (50% pruning of last season growth)

T₁₅: 5.0 m × 5.0 m (No pruning)

T₁₆: 5.0 m × 5.0 m (50% pruning of last season growth)

T₁₇: 6.0 m × 6.0 m (No pruning)

T₁₈: 6.0 m × 6.0 m (50% pruning of last season growth)

Design = Randomized Block Design (RBD)

Replications per treatment = 3

Tree per replication = 1

Total number of experimental trees = $18 \times 3 \times 1 = 54$

3.2 Microclimate parameters/ Meteorological observations

Observations on solar radiation interception, canopy temperature and relative humidity were recorded at 30 days interval starting from April 2016 till February 2017 in different parts of the tree canopy. The tree was divided into three parts viz. upper 1/3, middle 1/3, lower 1/3 and observations were recorded from these portions of trees.

3.2.1 Solar radiation interception

Radiation measurements were made on the clear days thrice a day (i. e. 8.00-10.00 am, 12.00-2.00 pm and then at 4.00-6.00 pm) by recording the sensor output from a

pyranometer using a Digital Multi-Voltmeter. The pyranometer measures the total direct and diffuse solar radiation. Incoming solar radiation measurements ($\text{Cal/cm}^2/\text{min}$) were recorded at one feet above the canopy and at the centre of upper, middle and lower parts of the tree by the pyranometer facing upward. The pyranometer was inverted at a height of one feet above the canopy to see the tree canopy below and thus the amount of reflected short wave radiation [Albedo (A)] was recorded. Radiation interception (to be reported light interception in this study) was calculated as the difference between incoming radiation received above the tree canopy and radiation received in each of the three different parts of the tree canopy and was expressed as intercepted radiation at a particular time of observation.

$$\text{Radiation intercepted in the upper part} = \frac{I - (I_1 + A)}{I} \times 100 = X\%$$

$$\text{Radiation intercepted in the middle part} = \frac{I - (I_2 + A)}{I} \times 100 - X\% = Y\%$$

$$\text{Radiation intercepted in the lower part} = \frac{I - (I_3 + A)}{I} \times 100 - Y\% = Z\%$$

Total interception by the tree canopy = X + Y + Z

Where,

I = Incoming solar radiation received one feet above top of the tree canopy.

I_1 = Incoming radiation received in the upper part of the tree canopy.

I_2 = Incoming radiation received in the middle part of the tree canopy.

I_3 = Incoming radiation received in the lower part of the tree canopy.

Due to non functioning of instrument data was taken only for rainy (April-September) season crop.

3.2.2 Canopy temperature ($^{\circ}\text{C}$)

The tree canopy temperature was recorded midway in the upper, middle and lower part of the tree with the help of infra-red thermometer thrice a day (i.e. at 8.00-10.00 am, 12.00-2.00 pm and 4.00-6.00 pm) on the same days when the data for radiation were recorded. The Infra-red thermometer was inclined at an angle of 45° while recording observation on different parts of the tree.

3.2.3 Relative humidity (%)

A psychron was used to record dry and wet bulb temperature. These observations were recorded midway in the upper, middle and lower parts of tree canopy thrice a day (i.e. at 8.00-10.00 am, 12.00-2.00 pm and 4.00-6.00 pm) on the days when data for radiation and tree canopy temperature were recorded. Relative humidity was calculated from dry and wet bulb temperature using psychrometric tables.

3.2.4 Chlorophyll fluorescence (F_v/F_m)

Chlorophyll fluorescence was recorded using CIP chlorophyll fluorescence Os-30P meter at midday (between 10.00 AM to 12:00 AM). The fully expanded leaf was first

acclimated to dark for minimum two minutes by fixing clip on it. The dark adapted leaf was then continuously irradiated for one second ($1500 \mu\text{mol m}^{-2}\text{s}^{-1}$) provided by an array of three light emitted diodes in the sensor. The Fv/Fm ratio was recorded.

3.3 Vegetative characters

3.3.1 Tree trunk cross- sectional area (Cm²)

Stem girth of the tree which was measured at 20 cm above ground was converted into cross trunk sectional area by using the formula of Glenn and Rogers (1964). Tree trunk cross-sectional has been expressed in cm².

$$\text{C.T.S.A.} = (\text{Girth})^2 / 4$$

3.3.2 Tree height (m)

The height of the tree was measured from the soil surface to the highest crown level with the help of a calibrated pole and expressed in meter.

3.3.3 Tree spread (m)

The spread of the tree was measured in both directions i.e., East-West and North-South and calculated by the following formula:

$$\text{Tree spread} = \frac{(\text{E-W}) + (\text{N-S})}{2}$$

Tree spread has been expressed in meter.

3.3.4 Canopy volume (cm³)

The canopy volume was calculated by the formula of Westwood *et al.* (1963)

$$\text{Canopy volume (m}^3\text{)} = 4/3 \ a^2b$$

Where,

a = half of the spread

b = half of the height

3.3.5 Shoot length (m)

Ten randomly selected shoots after pruning in April each of three trees of each treatment were tagged from all the directions of the tree and their length was measured at monthly interval upto February and expressed in meter.

3.3.6 Chlorophyll 'a' and 'b' content of the leaves (mg/100g)

Leaf discs (0.03 g) were washed, blotted dry and dipped in test tubes containing 3 ml of dimethyl sulfoxide (DMSO) for overnight as described by Sawhney and Singh, (2002). The extracted chlorophyll in DMSO was estimated by recording its absorbance at 663 and 645 nm, respectively and its amount was calculated from the formula:

$$\text{Chl 'a'} = \frac{12.3 A_{663} - 0.86 A_{645}}{a \times 1000 \times W} \times V$$

$$\text{Chl 'b'} = \frac{19.3 A_{645} - 3.6 A_{663}}{a \times 1000 \times W} \times V$$

Where,

V = Volume of DMSO

a = Path length

W = Weight of tissue taken

3.3.7 Leaf area (cm²)

Five months old leaves from 3rd and 4th positions from the base of the shoot were used for this purpose. A random sample of 10 leaves per side was picked from previously tagged shoots from all the directions on the tree. Thus, hundred leaves per treatment were used. The leaf area was measured with the help of leaf area meter (LICOR-USA) and expressed in square centimeters.

3.3.8 Leaf area index

Leaf area index was measured with the help of precalibrated, preprogrammed LAI-2000 plant canopy analyzer (LICOR-USA). Each value was computed on the basis of one open and four beneath canopy readings. Sensor of the canopy analyzer was held parallel to the eyes above the canopy of the ground crops to record open reading. Thereafter the sensor was held underneath the canopy near the base of crops 2-4 cm above the ground level to take 4 readings below canopy. Open and below canopy readings were taken using 45° view cap. Each value of LAI is the mean of three replications and has been expressed as unit less attribute.

3.4 Flower and fruit characters

3.4.1 Duration of flowering

Four representative branches well spread around the periphery of the trees were selected and data on duration of flowering were recorded from initiation of flowering to full bloom. The observation was taken for both rainy and winter season crop.

3.4.2 Duration of full bloom

The date on which more than 75% of flowers were open was considered as the time of full bloom. The observation was taken for both rainy and winter season crop.

3.4.3 End of flowering

Appearance of 20 number of flowers in a particular date towards last phase of flowering during rainy and winter season was recorded as the date of end of flowering.

3.4.4 Flower bud density

Two tertiary shoots (one meter) of medium vigour each in the upper, middle and lower part of the canopy for each plant were randomly selected and tagged. Numbers of flowers on each shoot were counted and average was worked out.



Plate 2. Experimental tree on flowering and bearing stages of guava cv. Hisar Safeda

3.4.5 Fruit set (%)

The per cent fruit set was calculated after one month anthesis from four tagged branches. The average per cent fruit set calculated by the formula given below.

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flowers}} \times 100$$

3.4.6 Fruit retention (%)

Fruit retention was noted at the time of final harvesting, when the fruit were fully mature. The total number of fruits harvested was counted and the percent fruit retention was calculated as below:

$$\text{Fruit retention (\%)} = \frac{\text{Total number of fruit retained}}{\text{Total number of fruits initially set}} \times 100$$

3.4.7 Fruit drop (%)

Fruit drop at time of harvesting was calculated by counting the number of fruits and subtracting it from the number of fruits at the time of fruit set and calculated on per cent basis.

$$\text{Fruit drop (\%)} = \frac{\text{Total number of dropped fruits}}{\text{Total number of fruits set}} \times 100$$

3.5 Fruit yield

3.5.1 Number of fruits per tree

A total number of fruits per plant were recorded by counting the harvested fruits in different picking in each replication under each treatment.

3.5.2 Fruit weight (g)

Five randomly selected fruits from different position of the tree were picked and weighed on top pan electric balance. The average weight was calculated by dividing the total fruit weight by total number of fruits taken and expressed in gram (g).

3.5.3 Fruit size (cm)

The fruit size was recorded in terms of length and diameter of fruit. Maximum length and diameter of the fruits were measured with the help of vernier callipers and mean values of length and diameter was presented in cm.

3.5.4 Yield per tree (Kg)

The total fruit yield per tree was calculated by multiplying a total number of fruits per tree with average fruit weight and expressed in kg per tree.

3.5.5 Yield per hectare (tonnes)

The yield of fruits per hectare was calculated by multiplying the yield of fruit per plant with number of plants per hectare.

3.5.6 Fruiting density (number/m³)

Fruiting density was calculated by dividing the number of fruits per tree with tree canopy as given below:

$$\text{Fruiting density} = \frac{\text{Number of fruits on a tree}}{\text{Canopy volume (m}^3\text{)}}$$

3.5.7 Yield efficiency

Yield efficiency can be determined by the following formula

$$\text{Yield efficiency (\%)} = \frac{\text{Average fruit load on tree (kg)}}{\text{Canopy volume (m}^3\text{)}} \times 100$$

3.6 Fruit quality parameters

3.6.1 Fruit firmness (lb/inch²)

The fruit firmness was determined with the help of penetrometer after removing about one square cm of skin from three sides of the fruit at shoulder end. The firmness was expressed in lb/inch².

3.6.2 Total soluble solids (%)

Pulp of three randomly selected fruits was crushed for extracting juice. Total Soluble Solids were measured with the help of digital refractometer and expressed as per cent soluble solids.

3.6.3 Total sugar (%)

Total sugar were estimated as per the method described by Hulme and Narain (1931).

Extraction

Five grams of fruit pulp from random sample was macerated with distilled water. It was kept on boiling water bath for a half an hour. Four to five extraction were made, these were cooled and made volume to 50ml.

Reagents:

- i) **Potassium ferricyanide solution:** Dissolved 8.25g potassium ferricyanide and 10.6g anhydrous sodium carbonate in distilled water and made the volume to one liter with distilled water. The solution was kept in amber coloured bottles and used after 3days of preparation.
- ii) **Potassium iodide solution:** Dissolved 12.5 g potassium iodide, 25 g zinc sulphate 125 g sodium chloride in distilled water and made the volume 500 ml with distilled water.
- iii) **Acetic acid solution:** Dissolved 50 ml glacial acetic acid in distilled water and made the volume 1 liter with distilled water.
- iv) **Sodium thiosulphate solution (N/100):** Dissolved 2.482 g sodium thiosulphate in distilled water and made the volume I liter with distilled water.
- v) **Starch indicator:** Dissolved 1 g soluble starch and 20 g sodium chloride in distilled water and made volume 100 ml with distilled water.

ESTIMATION

Total sugar

The total sugar were also estimated by method given by Hulme and Narain (1931) 10 ml of diluted extract was taken in a 50 ml volumetric flask and 2 ml of concentrated HCl was added to it. Then it was kept for hydrolysis for 10 minutes at 68°C. This solution was

neutralized by adding sodium carbonate (Solid) till the effervescence stopped. Then the volume was made to 50 ml by adding distilled water. Five ml of sugar solution and five ml of potassium ferricyanide solution were taken for each sample in a test tube. The tubes covered and kept for 15 minutes in boiling water bath. The tubes were then cooled under tap water and five ml potassium iodide solution followed by three ml acetic acid solution (5%) was added in each tube. The liberated Iodide was titrated with sodium thiosulphate (N/100) using starch as indicator. The end point was the disappearance of blue colour and appearance of milky white colour. A blank with five ml of distilled water was also run simultaneously.

The result was calculated by the following formula and expressed in gram of sugar per 100 gram fresh weight.

$$X = [(ml \text{ of sodium thiosulphate used in blank} - ml \text{ of sodium thiosulphate used in unknown}) + 0.05] \times 0.338 = \text{mg of sugar/ 5 ml extract.}$$

$$\text{Total sugar \%} = \frac{X' \times \text{dilution factor}}{5 \times 100} \times 100$$

3.6.4 Ascorbic acid (mg/100g pulp)

The ascorbic acid content was determined by the standard method (AOAC, 2000).

Extraction

Two grams of fruit pulp was taken and macerated in pestle and mortar with small amount of 3 per cent metaphosphoric acid solution and filtered through muslin cloth. Final volume was made to 25 ml with 3 per cent metaphosphoric acid. 15 g of metaphosphoric acid was dissolved in 40 ml of glacial acetic acid. Final volume was made to 500 ml with distilled water.

I. 2,6 dichlorophenol indophenol dye

2,6 dichlorophenol indophenol dye $C_{12}H_6Cl_2NaO_2 \cdot 2H_2O$ - 50 mg.

Sodium bicarbonate $NaHCO_3$ - 42mg.

50 mg of 2,6 dichlorophenol indophenol dye and 42 mg Sodium bicarbonate was dissolved in 10 ml of distilled water. Final volume was made to 200 ml with distilled water. Dye was filtered and stored in dark coloured bottle at low temperature.

II. Standard ascorbic acid solution (St.)

50 mg of ascorbic acid ($C_6H_8O_6$) was dissolved in 50ml of 3 per cent metaphosphoric acid.

Estimation

Two ml of aliquot was pipetted into a conical flask and titrated against 2,6 dichlorophenol indophenol dye until distinctly rose pink colour persisted at least for 5 seconds. Simultaneously, 1ml of standard ascorbic acid was titrated against the dye. The result were expressed as mg of ascorbic acid per 100 g of fruit pulp.

Caculation

$$\text{Ascorbic acid (mg/100g fruit pulp)} = \frac{\text{Titrate value} \times \text{Total volume}}{\text{St. reading} \times \text{ml of sample}} \times 100$$

3.6.5 Titratable acidity (%)

The method suggested by AOAC (2000) was followed for estimation of titratable acidity.

Reagents prepared: The following reagents were prepared for following further use.

1. Sodium hydroxide 0.1N
2. Phenolphthalein indicator 1 per cent

Procedure

Two grams of fruit pulp was mixed with small amount of distilled water and the volume was made to 25 ml. Few drops of 1 per cent of phenolphthalein indicator were added and titrated against N/10 sodium hydroxide taken in burette. Appearance of light pink colour lasting for a minute or longer indicated the end point. Acidity was expressed in term of citric acid.

Calculation:

$$\text{Acidity (\%)} = \frac{\text{Titrate value} \times \text{Normality of NaOH} \times \text{Eq. weight of citric acid}}{\text{Juice taken (ml)} \times 100} \times 100$$

3.7 Estimation leaf of NPK

3.7.1 Estimation of total nitrogen

Total nitrogen was determined by micro-Kjeldahl method (AOAC, 1970). A sample weighing 0.2 g was taken into a micro-Kjeldahl flask and digested with 10 ml of concentrated H₂SO₄ in the presence of catalyst powder (200g K₂SO₄ + 20g CuSO₄ + 2g Se) at full heat (150°C for 45 minutes and then at 35⁰C for another 45 minutes). The digestion is continued for about 1 hour after the solution was clear. The digests were then distilled and liberated ammonia was collected in 4 per cent boric acid solution containing bromocresol green and methyl red mixed indicator. This solution was backtitrated against 0.1N HCl. Three samples from each treatment were analysed and average nitrogen content was calculated and expressed as per cent on dry weight basis.

$$\text{Nitrogen (\%)} = \frac{(S - B) \times N \times 0.014 \times 100}{\text{Weight of sample}}$$

Where,

S = Acid used for sample (ml)

B = Acid used for blank (ml)

N = Normality of acid

3.7.2 Estimation of phosphorus

Phosphorus content of leaf samples was determined by “Vandomolybdophosphoric yellow colour method” as described by Jackson (1973). Five ml aliquot was taken in 25 ml volumetric flask to which 2.5 ml of Barton's reagent was added and the volume was made



Plate 3. Experimental tree fruits size of guava cv. Hisar Safeda harvested from different parts of tree canopy

upto the mark. The intensity of yellow colour of “phosphovandomolybdic complex” was measured at 470 nm with the help of a spectrophotometer (Spectronic 20). The standard curve was prepared from different concentrations of potassium dihydrogen orthophosphate. The results were expressed in per cent on dry weight basis.

3.7.3 Estimation of potassium

Total potassium content in the samples was determined with the help of flame photometer (Chapman and Pratt, 1961). Five ml of aliquot was taken in a 25 ml volumetric flask and diluted to 25 ml to which the galvanometer reading was noted by using potassium filter. Standard potassium curve was obtained from different concentrations of potassium chloride. The results were expressed in per cent on dry weight basis.

3.8 Statistical analysis

The data presented in this thesis were the mean value of different parameters. The statistical method described by Panse and Sukatme (1967) was followed for the analysis and interpretation of the experimental results. In order to evaluate comparative performance of the various treatments, the data were analyzed by the technique of analysis of variance described by Fisher (1958). All the tests of significance were made at 5% level of the significance. To judge the significance of the difference between two results, the critical difference (CD) was worked out by following formula:

$$\text{C.D. at 5\%} = \sqrt{\frac{2 \times \text{error mean square}}{n}} \times t \text{ value (5\%)}$$

Where,

C.D. = Critical difference

n = No. of observations

t = Value of t-distribution at 5% level of error degree of freedom

The data was analyzed with the help of windows based computer package OPSTAT (Sheoran, 2004), which calculate the standard error of means (SEm), standard error of the difference in mean (SEd) and critical difference (CD) between the treatments at 5% level of significance.

The results of the present investigation entitled “**Studies on canopy management in high density planting of guava (*Psidium guajava* L.)**” have been presented in this chapter under the appropriate heads and sub-heads:

4.1 Microclimate parameters/ Meteorological observations

4.1.1 Solar radiation interception

The perusal of data given in table 1 reveals that the solar radiation interception was significantly increased with increasing spacings and pruning levels during the rainy season. Mean solar radiation interception by the plants was recorded significantly higher (22.8%) in wider spacing (6× 6 m) as compared to other trees planted at 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m spacing whereas, minimum (18.2%) solar radiation interception was observed in closer spacing (5× 2 m) trees. The solar radiation interception was significantly affected by the pruning treatments. Pruned trees received 21.2 per cent solar radiation interception whereas, un-pruned trees received 20.4 per cent solar radiation. The solar radiation interception was also significantly affected by the different parts of tree canopy. The upper part of the tree canopy intercepted significantly higher (44.4%) solar radiation as compared to the middle (11.4%) and lower (6.5%) canopy parts. The interaction between spacing and pruning for solar radiation interception was found significant. Maximum solar radiation interception (23.3%) was recorded in wider spacing (6×6 m) of pruned trees as compared to other spacing of pruned and un-pruned trees and minimum solar radiation interception (18.0%) was observed in closer spacing (5× 2 m) of un-pruned trees. Interaction effect between spacing and canopy for solar radiation interception was also found significant. Upper canopy part of wider spacing plants (6×6 m) intercepted significantly higher (47.9%) solar radiation as compared to all other canopy part of different spacings trees whereas, minimum solar radiation interception (5.2%) was observed in the lower canopy part of closer spacing trees (5×2 m). Interaction effect between pruning and canopy for solar radiation interception by the plant was also found significant. Upper canopy part of pruned trees intercepted significantly higher (44.9 %) solar radiation as compared to middle and lower canopy part of non pruned and pruned trees. While lower canopy part of un-pruned trees intercepted significantly lower (6.2%) solar radiation. Interaction among the spacing, pruning and canopy showed statistically non significant effect for solar radiation interception.

Table1: Effect of spacing, pruning and the part of tree canopy on solar radiation interception (%) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	41.1	9.9	5.2	42.9	10.9	5.9		
6 x 3	43.1	11.0	6.0	44.5	12.0	6.6		
6 x 4	45.1	11.9	6.5	46.0	12.0	7.2		
6 x 5	46.2	12.1	7.1	47.0	12.9	7.8		
5 x 2	40.1	9.0	4.9	40.4	9.1	5.5		
5 x 3	42.2	10.5	5.4	43.7	11.2	6.4		
5 x 4	44.6	11.6	6.2	44.9	11.9	6.9		
5 x 5	45.7	12.0	6.7	46.4	12.3	7.5		
6 x 6	47.2	12.5	7.3	48.5	13.2	8.1		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	18.7	20.0	19.3	6 x 2	42.0	10.4	5.5	19.3
6 x 3	20.1	21.0	20.5	6 x 3	43.8	11.5	6.3	20.5
6 x 4	21.2	21.7	21.5	6 x 4	45.6	12.0	6.9	21.5
6 x 5	21.8	22.5	22.2	6 x 5	46.6	12.5	7.5	22.2
5 x 2	18.0	18.3	18.2	5 x 2	40.3	9.0	5.2	18.2
5 x 3	19.4	20.5	19.9	5 x 3	43.0	10.9	5.9	19.9
5 x 4	20.8	21.3	21.0	5 x 4	44.8	11.8	6.6	21.0
5 x 5	21.5	22.1	21.8	5 x 5	46.1	12.2	7.1	21.8
6 x 6	22.3	23.3	22.8	6 x 6	47.9	12.9	7.7	22.8
Mean	20.4	21.2		Mean	44.4	11.4	6.5	
Pruning x Canopy (P x C)					CD (0.05)			
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	43.9	11.2	6.2	20.4	Spacing		0.2	
Pruned	44.9	11.7	6.9	21.2	Pruning		0.1	
Mean	44.4	11.4	6.5		Canopy		0.1	
					Spacing x Pruning		0.3	
					Spacing x Canopy		0.3	
					Pruning x Canopy		0.2	
					Spacing x Pruning x Canopy		NS	

4.1.2 Canopy temperature

The data regarding canopy temperature in different parts of the tree canopy under different spacings and pruning treatments during the rainy and winter seasons is given in tables 2 and 3.

Data presented in Table 2 clearly indicates that canopy temperature increased significantly with increasing spacing during the rainy season. The canopy temperature was significantly affected by the plant spacings. Maximum mean canopy temperature (31.9 °C) was recorded in trees spaced at

6×6 m as compared to all other trees spaced at 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m, whereas, minimum mean canopy temperature (26.3°C) was observed in trees spaced at 5×2 m. The canopy temperature was also significantly affected by the pruning treatments. Mean canopy temperature was recorded 29.0 °C in pruned trees whereas in un-pruned trees it was 28.5 °C. The canopy temperature was significantly affected by the different parts of tree canopy. Mean canopy temperature was found significantly higher (30.1 °C) in upper part of tree canopy than other middle and lower part of tree canopy. The interaction effect between spacing and pruning as well as pruning and canopy were statistically found non significant. The interaction between spacing and canopy was found significant. Mean canopy temperature was recorded significantly higher (33.7%) in wider spacing (6×6 m) of upper canopy part as compared to all other spacings of different canopy parts, whereas minimum canopy temperature (25.3 °C) was noticed in closer spacing (5× 2 m) of lower canopy part. Interaction among the spacing, pruning and canopy was statistically found significant. Maximum canopy temperature (33.7 °C) which was found significantly higher was recorded in 6×6 m spacing of pruned trees of upper part of tree canopy whereas, minimum canopy temperature (24.8 °C) was recorded in 5× 2 m spacing of un-pruned trees of lower canopy part.

Further, the data presented in table 3 shows that canopy temperature increased significantly with the increasing spacing and pruning levels during the winter season. Maximum mean canopy temperature (23.9 °C) was recorded in trees spaced at 6× 6 m which is significantly higher as compared to all other spacings whereas, minimum mean canopy temperature (18.0 °C) was found in trees spaced at 5×2 m. The canopy temperature was also significantly affected by the pruning treatments. Mean Canopy temperature 21.8 °C was recorded in pruned trees and in un-pruned trees it was noticed 21.2 °C. The canopy temperature was also significantly affected by the different parts of tree canopy. The mean canopy temperature was recorded significantly higher (23 °C) in upper part of tree canopy than other part of tree canopy and lesser (19.6 °C) was noticed in lower part of tree canopy. The interaction between spacing and pruning was found significant. Maximum canopy temperature (24.0 °C) was recorded in 6×6 m spacing of pruned trees whereas, minimum canopy temperature (18.7 °C) was found in 5×2 m spacing of un-pruned trees. The interaction effect between spacing and canopy was also found significant. Mean canopy temperature was observed significantly higher (25.4 °C) in 6×6 m spacing of upper canopy part of trees as compared to all other spacing of different canopy part whereas, minimum canopy temperature (16.2 °C) was recorded in 5× 2 m spacing of lower canopy part. The interactive effect between pruning and canopy as well as among the spacing, pruning and canopy on canopy temperature was statistically found non significant.

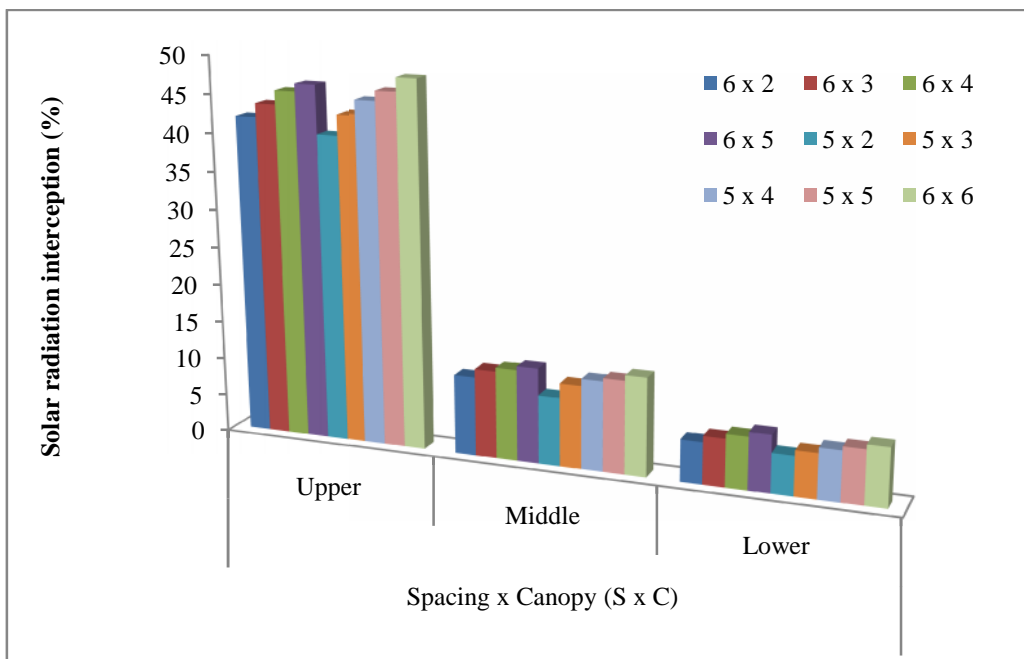
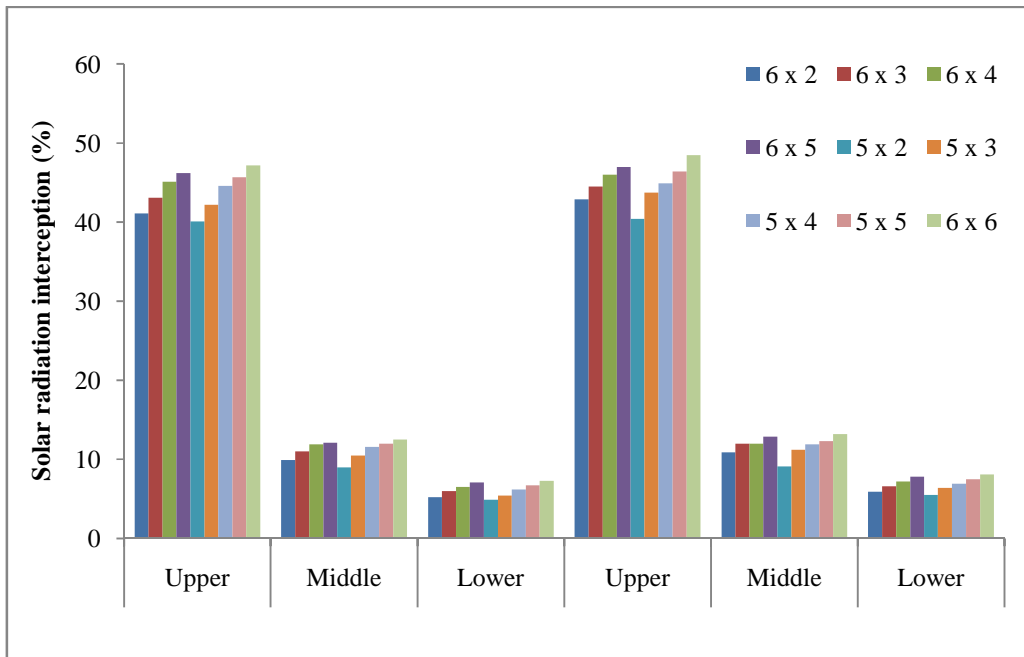


Fig. 1: Effect of spacing, pruning and the part of tree canopy on solar radiation interception (%) during the rainy season in guava cv. Hisar Safeda

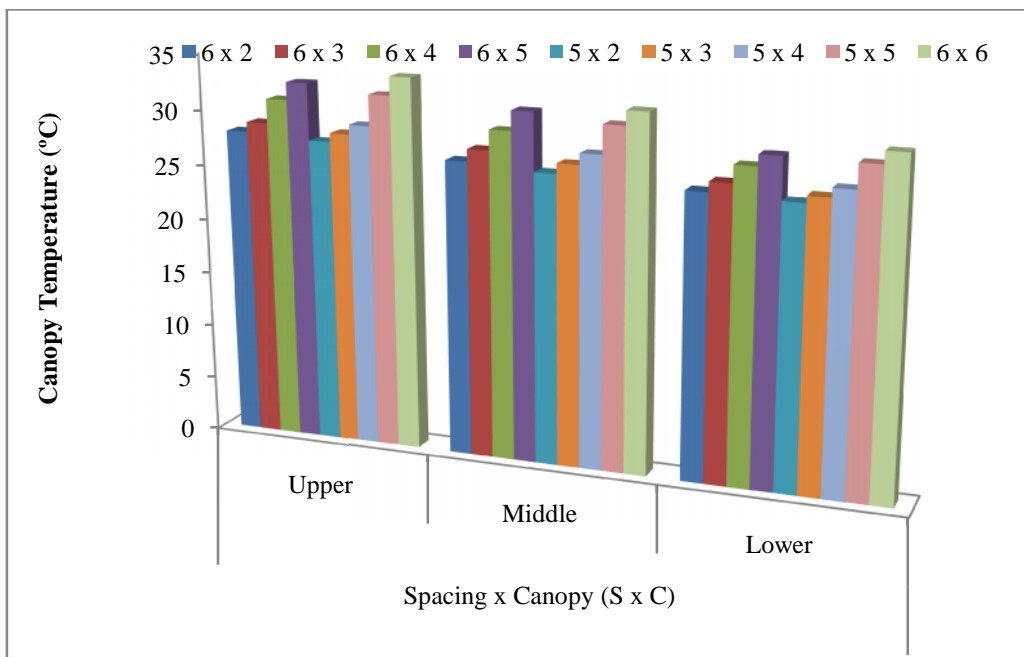
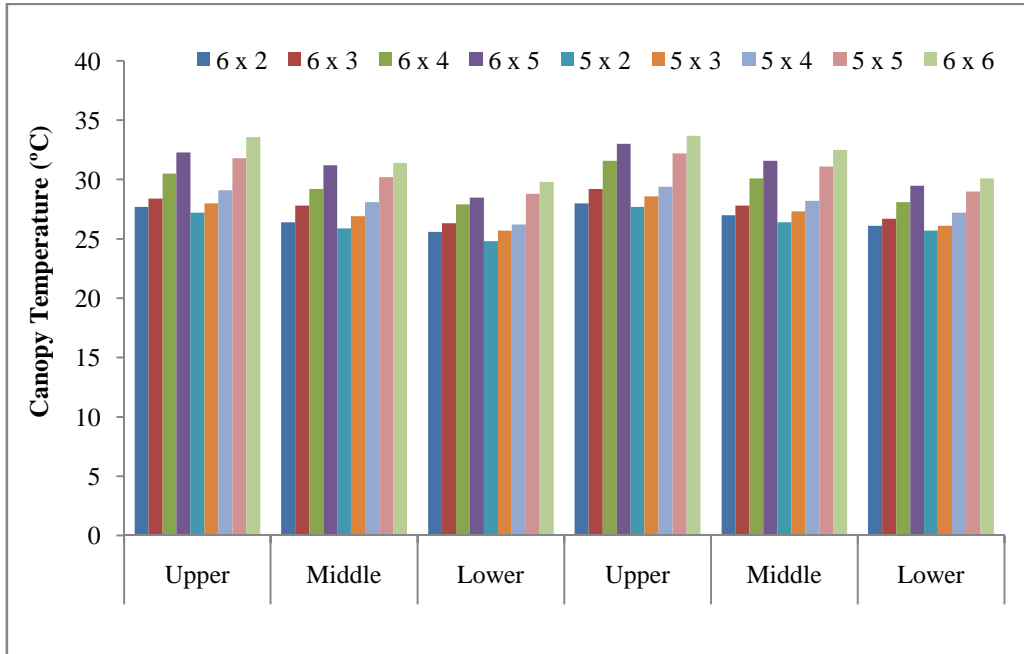


Fig. 2: Effect of spacing, pruning and the part of tree canopy on canopy temperature (°C) during the rainy season in guava cv. Hisar Safeda

Table 2: Effect of spacing, pruning and the part of tree canopy on canopy temperature (°C) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	27.7	26.4	25.6	28.0	27.0	26.1		
6 x 3	28.4	27.8	26.3	29.2	27.8	26.7		
6 x 4	30.5	29.2	27.9	31.6	30.1	28.1		
6 x 5	32.3	31.2	28.5	33.0	31.6	29.5		
5 x 2	27.2	25.9	24.8	27.7	26.4	25.7		
5 x 3	28.0	26.9	25.7	28.6	27.3	26.1		
5 x 4	29.1	28.1	26.2	29.4	28.2	27.2		
5 x 5	31.8	30.2	28.8	32.2	31.1	29.0		
6 x 6	33.6	31.4	29.8	33.7	32.5	30.1		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	26.4	27.0	26.7	6 x 2	27.9	26.7	25.6	26.7
6 x 3	27.5	27.9	27.7	6 x 3	28.8	27.8	26.5	27.7
6 x 4	29.2	29.9	29.6	6 x 4	31.0	29.6	28.03	29.6
6 x 5	30.7	31.4	31.0	6 x 5	32.6	31.4	29.03	31.0
5 x 2	26.0	26.6	26.3	5 x 2	27.5	26.2	25.3	26.3
5 x 3	26.9	27.4	27.1	5 x 3	28.3	27.1	25.9	27.1
5 x 4	27.8	28.2	28.0	5 x 4	29.2	28.1	26.7	28.0
5 x 5	30.3	30.8	30.5	5 x 5	32.0	30.7	28.9	30.5
6 x 6	31.6	32.1	31.9	6 x 6	33.7	32.0	30.0	31.9
Mean	28.5	29.0		Mean	30.1	28.9	27.3	
Pruning x Canopy (P x C)					CD (0.05)			
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	29.9	28.6	27.0	28.5	Spacing			0.2
Pruned	30.4	29.1	27.6	29.0	Pruning			0.1
Mean	30.1	28.9	27.3		Canopy			0.1
					Spacing x Pruning			NS
					Spacing x Canopy			0.4
					Pruning x Canopy			NS
					Spacing x Pruning x Canopy			0.6

Table 3: Effect of spacing, pruning and the part of tree canopy on canopy temperature (°C) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)									
Pruning →	Non pruned (Np)			Pruned (P)					
Canopy →	Upper	Middle	Lower	Upper	Middle	Lower			
Spacing(m) ↓									
6 x 2	20.4	19.3	18.5	21.2	20.3	19.0			
6 x 3	22.3	21.2	18.9	22.9	21.9	19.5			
6 x 4	24.0	22.8	20.5	23.8	22.6	20.3			
6 x 5	25.0	23.3	20.9	25.2	24.1	21.9			
5 x 2	19.0	17.3	15.7	19.9	19.4	16.8			
5 x 3	20.5	19.4	18.1	21.4	20.5	19.1			
5 x 4	23.4	21.1	20.3	23.9	22.6	21.5			
5 x 5	24.4	23.0	20.7	25.2	23.6	21.2			
6 x 6	25.3	24.1	21.9	25.6	24.2	22.3			
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)					
Pruning →	Non Pruned	Pruned	Mean (S)	Canopy →	Upper	Middle	Lower	Mean (S)	
Spacing(m) ↓					Spacing(m) ↓				
6 x 2	19.2	20.2	19.7	6 x 2	20.8	19.8	18.5	19.7	
6 x 3	20.8	21.4	21.1	6 x 3	22.6	21.5	19.2	21.1	
6 x 4	22.5	22.2	22.4	6 x 4	23.9	22.7	20.4	22.3	
6 x 5	23.1	23.7	23.4	6 x 5	25.1	23.7	21.4	23.4	
5 x 2	17.3	18.7	18.0	5 x 2	19.5	18.4	16.2	18.0	
5 x 3	19.3	20.3	19.8	5 x 3	20.9	20.0	18.6	19.8	
5 x 4	21.9	22.4	22.2	5 x 4	23.7	22.4	20.4	22.2	
5 x 5	22.7	23.3	23.0	5 x 5	24.8	23.3	20.9	23.0	
6 x 6	23.8	24.0	23.9	6 x 6	25.4	24.2	22.1	23.9	
Mean	21.2	21.8		Mean	23.0	21.8	19.6		
Pruning x Canopy (P x C)					CD (0.05)				
Canopy →	Upper	Middle	Lower	Mean					
Pruning ↓					Spacing			0.3	
Non pruned	22.7	21.4	19.4	21.2	Pruning			0.1	
Pruned	23.2	22.1	20.1	21.8	Canopy			0.2	
Mean	23.0	21.8	19.8		Spacing x Pruning			0.4	
					Spacing x Canopy			0.4	
					Pruning x Canopy			NS	
					Spacing x Pruning x Canopy			NS	

4.1.3 Relative humidity

Data related to relative humidity was given in table 4 and 5 during the rainy and winter seasons, respectively.

The perusal of data in table 4 clearly indicates that relative humidity was significantly different among the various treatments and canopy parts during the rainy season. Relative humidity decreased with increasing spacing and pruning levels. The relative humidity was significantly affected by the plant spacings. Maximum mean relative humidity (56.5%) was found in 5×2 m spacing which is significantly higher than all other spacings and it was

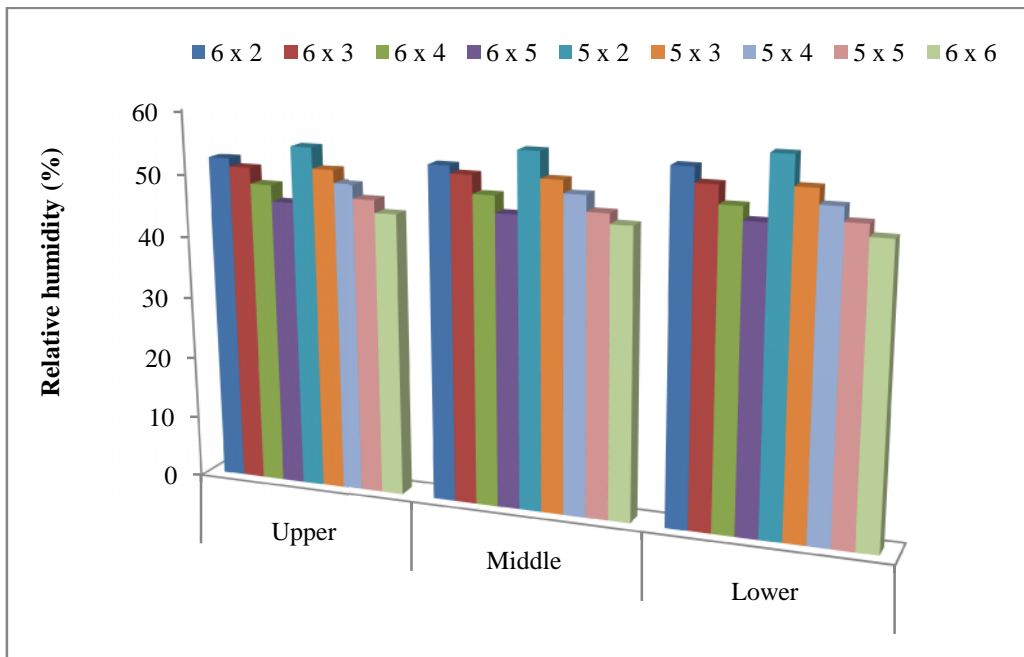
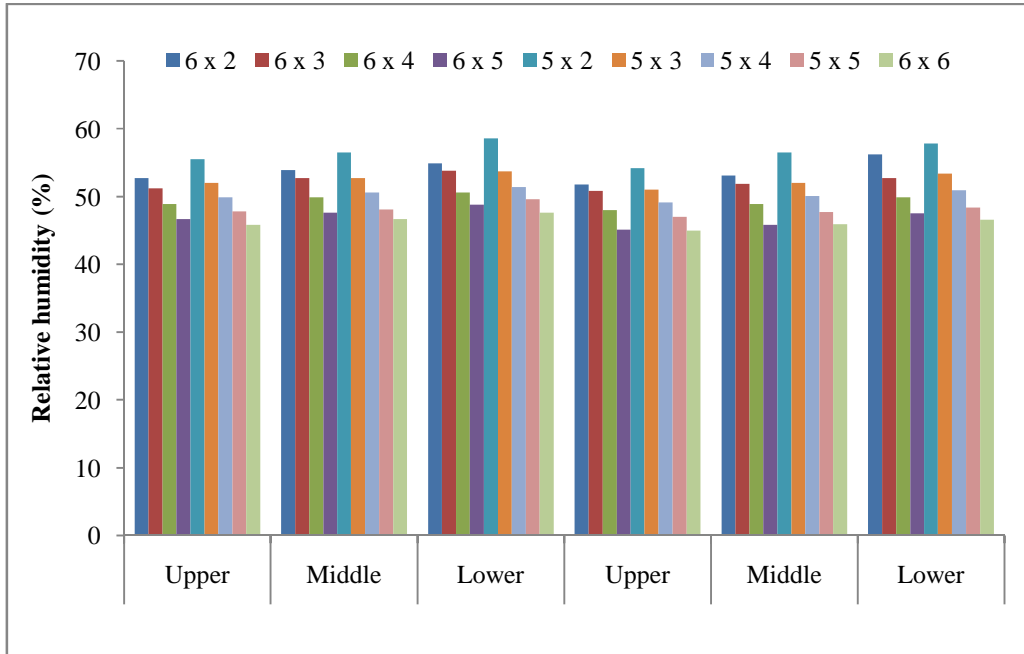


Fig. 3: Effect of spacing, pruning and the part of tree canopy on relative humidity (%) during the rainy season in guava cv. Hisar Safeda

minimum (46.3%) in 6×6 m spacing. The relative humidity also significantly affected by the pruning treatments. Relative humidity was noticed 51.1 per cent in un-pruned trees whereas, in pruned trees it was observed 50.3 per cent. The relative humidity was significantly affected by the different parts of tree canopy. It was recorded significantly higher (51.8%) in lower part of canopy than middle and upper part of tree canopy. Interaction effect between spacing and pruning was found significant. Highest relative humidity (56.8%) was recorded in closer spacing (5×2 m) of un-pruned trees which was significantly higher than all other spacings and pruning treatments whereas, lesser relative humidity (45.8 %) was observed in wider spacing (6×6 m) of pruned trees. The interaction between spacing and canopy was also found significant. Maximum relative humidity (58.2%) was recorded in lower canopy part of closer (5×2 m) spacing trees which is significantly higher than to all other canopy part of different spacing trees whereas, minimum relative humidity (45.4 %) was noticed in upper canopy part of wider spacing (6×6 m) trees. The interaction effect between pruning and canopy was also statistically found significant. Maximum relative humidity (52.1%) was recorded in lower canopy part of un-pruned trees as compared to all other canopy part of pruned and un-pruned trees. Interaction among the spacing, pruning and canopy was statistically found significant. Highest relative humidity (58.6%) was recorded in closer spacing of lower canopy part of un-pruned trees, which was found significantly higher than all other spacings of different canopy part of pruned and un-pruned trees. Lowest relative humidity (45.0 %) was observed in wider spacing (6×6 m) of upper canopy part of pruned trees.

The observation recorded on relative humidity during the winter season was significantly different among spacings, pruning levels and part of canopy (Table 5). The values show the average relative humidity to be maximum (71.9 %) in the trees spaced at 5×2 m which was significantly higher than relative humidity in the trees spaced at 5×3 m, 6×2 m, 5×4 m, 6×3 m, 6×4 m, 5×5 m and 6×5 m and it was minimum (58.0%) in trees spaced at 6×6 m. The relative humidity also significantly affected by the pruning treatments. The mean relative humidity 64.7 per cent was recorded in un-pruned trees whereas, in pruned trees it was 64.5 per cent. The relative humidity was significantly affected by the different parts of tree canopy. Maximum relative humidity (66.5%) was recorded in lower part of tree canopy as compared to middle and upper part of tree canopy whereas, it was minimum (63.0%) in upper part of tree canopy. The interaction between spacing and pruning was found non significant. Irrespective of pruning interaction between spacing and canopy was found significant. Maximum relative humidity (73.9 %) was recorded in lower canopy part of closer spacing (5×2 m) trees and minimum relative humidity (56.6%) was recorded in upper canopy part of wider spacing (6×6 m) trees. Interaction between pruning and canopy was found non significant, whereas interaction among the spacing, pruning and canopy was also found non significant.

Table 4: Effect of spacing, pruning and the part of tree canopy on relative humidity (%) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	52.7	53.9	54.9	51.8	53.1	56.2		
6 x 3	51.2	52.7	53.8	50.8	51.9	52.7		
6 x 4	48.9	49.9	50.6	48.0	48.9	49.9		
6 x 5	46.7	47.6	48.8	45.1	45.8	47.5		
5 x 2	55.5	56.5	58.6	54.2	56.5	57.8		
5 x 3	52.0	52.7	53.7	51.0	52.0	53.4		
5 x 4	49.9	50.6	51.4	49.1	50.1	50.9		
5 x 5	47.8	48.1	49.6	47.0	47.7	48.4		
6 x 6	45.8	46.7	47.6	45.0	45.9	46.6		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	53.9	53.7	53.8	6 x 2	52.3	53.5	55.6	53.8
6 x 3	52.5	51.8	52.1	6 x 3	51.0	52.3	53.2	52.1
6 x 4	49.8	48.9	49.4	6 x 4	48.5	49.4	50.3	49.4
6 x 5	47.7	46.1	46.9	6 x 5	45.9	46.7	48.2	46.9
5 x 2	56.8	56.2	56.5	5 x 2	54.8	56.5	58.2	56.5
5 x 3	52.8	52.1	52.5	5 x 3	51.5	52.4	53.6	52.5
5 x 4	50.7	50.0	50.3	5 x 4	49.5	50.4	51.2	50.3
5 x 5	48.5	47.7	48.1	5 x 5	47.4	47.91	49.0	48.1
6 x 6	46.7	45.8	46.3	6 x 6	45.4	46.3	47.1	46.3
Mean	51.1	50.3		Mean	49.6	50.6	51.8	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	50.1	51.0	52.1	51.1	Spacing			0.3
Pruned	49.1	50.2	51.5	50.3	Pruning			0.1
Mean	49.6	50.6	51.8		Canopy			0.2
					Spacing x Pruning			0.4
					Spacing x Canopy			0.4
					Pruning x Canopy			0.2
					Spacing x Pruning x Canopy			0.6

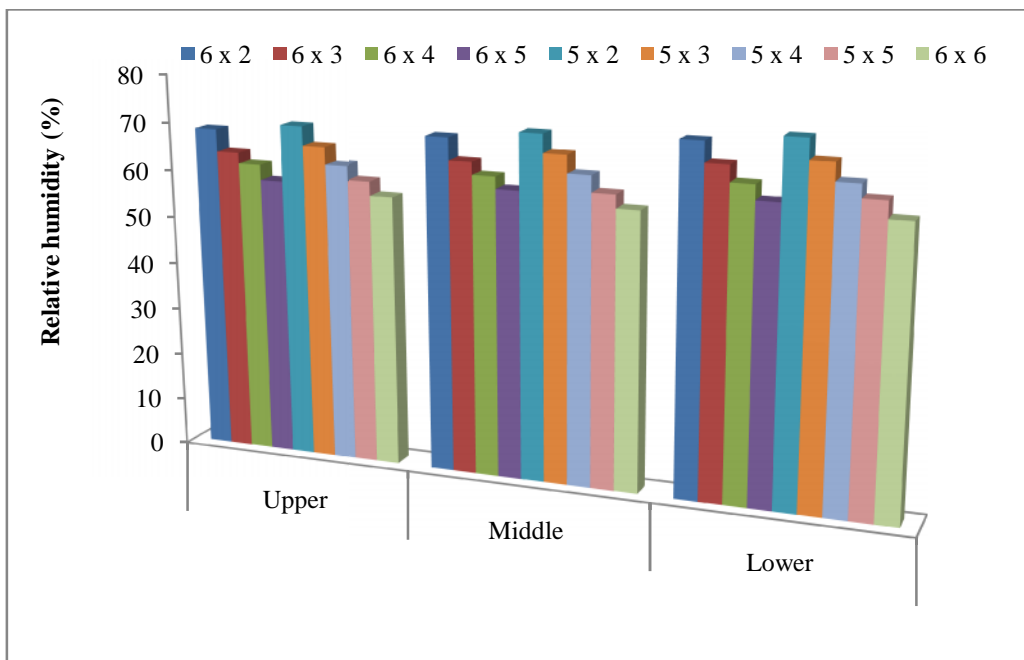
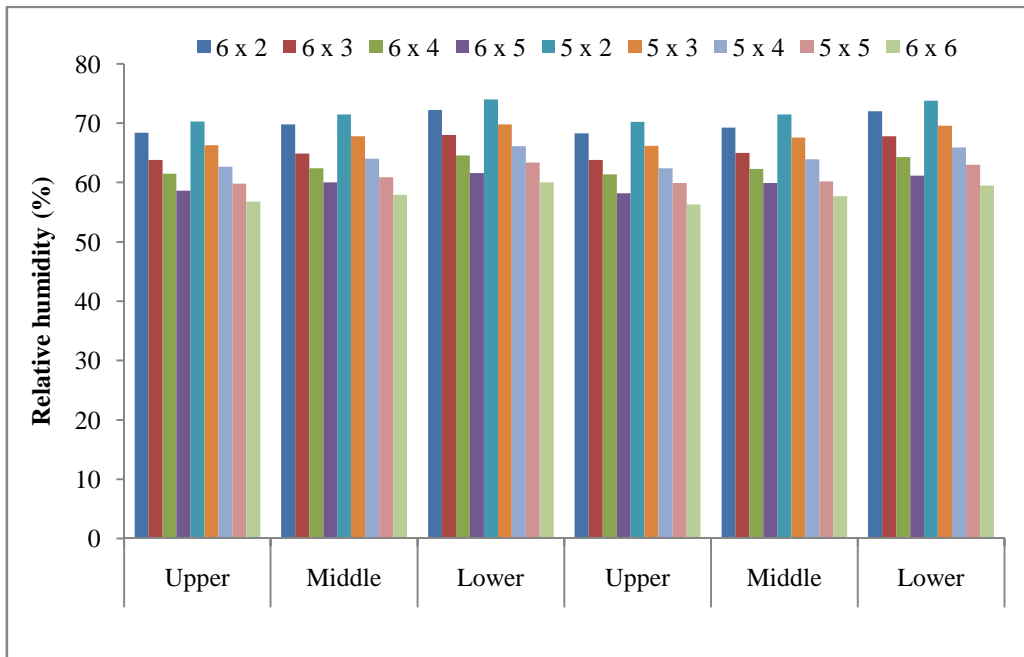


Fig. 4: Effect of spacing, pruning and the part of tree canopy on relative humidity (%) during the winter season in guava cv. Hisar Safeda

Table 5: Effect of spacing, pruning and the part of tree canopy on relative humidity (%) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	68.4	69.8	72.2	68.3	69.3	72.0		
6 x 3	63.8	64.9	68.0	63.8	65.0	67.8		
6 x 4	61.5	62.4	64.6	61.4	62.3	64.3		
6 x 5	58.6	60.0	61.6	58.2	59.9	61.2		
5 x 2	70.3	71.5	74.0	70.2	71.5	73.8		
5 x 3	66.3	67.8	69.8	66.2	67.6	69.6		
5 x 4	62.7	64.0	66.1	62.4	63.9	65.9		
5 x 5	59.8	60.9	63.4	59.9	60.2	63.0		
6 x 6	56.8	57.9	60.0	56.3	57.7	59.5		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning →	Non Pruned	Pruned	Mean (S)	Canopy Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	70.1	69.9	70.0	6 x 2	68.4	69.6	72.1	70.0
6 x 3	65.6	65.5	65.5	6 x 3	63.8	65.0	67.9	65.5
6 x 4	62.8	62.7	62.8	6 x 4	61.6	62.4	64.5	62.8
6 x 5	60.1	59.7	59.9	6 x 5	58.4	59.9	61.4	59.9
5 x 2	71.9	71.8	71.9	5 x 2	70.2	71.5	73.9	71.9
5 x 3	68.0	67.8	67.9	5 x 3	66.2	67.7	69.7	67.9
5 x 4	64.3	64.1	64.2	5 x 4	62.6	64.0	66.0	64.2
5 x 5	61.4	60.8	61.1	5 x 5	59.5	60.6	63.2	61.1
6 x 6	58.2	57.8	58.0	6 x 6	56.6	57.8	59.7	58.0
Mean	64.7	64.5		Mean	63.0	64.3	66.5	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy →	Upper	Middle	Lower	Mean	Spacing Pruning			0.2
Pruning ↓					Canopy			0.1
Non pruned	63.1	64.4	66.6	64.7	Spacing x Pruning			0.1
Pruned	62.9	64.2	66.4	64.5	Spacing x Canopy			NS
Mean	63.0	64.3	66.5		Pruning x Canopy			NS
					Spacing x Pruning x Canopy			NS

4.1.4 Chlorophyll fluorescence

Chlorophyll fluorescence significantly increased with the increasing spacing and pruning levels during the rainy and winter season (Table 6).

The observation on chlorophyll fluorescence during the rainy season revealed that there was significant variation exists among the different spacing and pruning treatments. Among the treatments chlorophyll fluorescence was found significantly higher (0.727 Fv/Fm) in trees spaced at 6×6 m as compared to other 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m spacings and minimum chlorophyll fluorescence (0.540 Fv/Fm) was recorded in trees

spaced at 5×2 m. The chlorophyll fluorescence was also significantly affected by the pruning treatments. The chlorophyll fluorescence 0.697 Fv/Fm was recorded in pruned trees whereas, in un-pruned trees it was found 0.603 Fv/Fm. The interaction between spacing and pruning was also statistically found significant. Maximum chlorophyll fluorescence (7.80 Fv/Fm) was recorded in wider spacing of pruned trees as compared all other spacing of pruned and un-pruned trees whereas, minimum (0.523 Fv/Fm) was recorded in closer spacing (5×2 m) of un-pruned trees.

Table 6: Effect of spacing and pruning on chlorophyll fluorescence (Fv/Fm) in guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	0.547	0.673	0.610	0.443	0.547	0.495
6 x 3	0.600	0.700	0.650	0.473	0.580	0.527
6 x 4	0.627	0.720	0.673	0.497	0.590	0.543
6 x 5	0.653	0.730	0.692	0.537	0.627	0.582
5 x 2	0.523	0.557	0.540	0.420	0.497	0.458
5 x 3	0.553	0.683	0.618	0.453	0.553	0.503
5 x 4	0.613	0.707	0.660	0.483	0.587	0.535
5 x 5	0.640	0.720	0.680	0.507	0.623	0.565
6 x 6	0.673	0.780	0.727	0.547	0.650	0.598
Mean	0.603	0.697		0.484	0.584	
	CD (0.05)			CD (0.05)		
	Spacing	0.010		Spacing	0.009	
	Pruning	0.005		Pruning	0.004	
	Spacing x Pruning	0.015		Spacing x Pruning	0.013	

It was also observed that chlorophyll fluorescence significantly different among the spacing and pruning treatments (Table 6) during the winter season. Among the treatments chlorophyll fluorescence was found significantly higher (0.598 Fv/Fm) in trees spaced at 6×6 m as compared to all other spacings and it was minimum (0.458 Fv/Fm) in trees spaced at 5×2 m. The chlorophyll fluorescence was also significantly affected by the pruning treatments. In pruned trees chlorophyll fluorescence was recorded 0.584 Fv/Fm whereas, in un-pruned trees it was 0.484 Fv/Fm. The interaction effect between spacing and pruning was also found significant. Among the treatments highest chlorophyll fluorescence (0.650 Fv/Fm) was observed in wider spacing (6×6 m) of pruned trees and minimum (0.420 Fv/Fm) was recorded in closer spacing (5×2 m) of un-pruned trees.

4.2 Vegetative characters

4.2.1 Tree trunk cross-sectional area

The perusal of data in table 7 clearly indicate that tree trunk cross sectional area was significantly different among the treatments. Tree trunk cross sectional area was significantly affected by the plant spacings. Maximum (161.9 cm²) mean tree trunk cross sectional area recorded in trees spaced at 6×6 m which was at par with at 6× 5 m and minimum was found (130.8 cm²) in trees spaced at 5×2 m. The tree trunk cross sectional area was also significantly affected by the pruning treatments. The tree trunk cross sectional area was observed 148.7 cm² in pruned trees whereas, it was 138.3 cm² in un-pruned trees. The interaction effect between spacing and pruning treatments was statistically found non significant.

Table 7: Effect of spacing and pruning on tree trunk cross sectional area (cm²) and height (m) of guava cv. Hisar safeda

Spacing (m)	Trunk cross sectional area (cm ²)			Tree height (m)		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	128.5	136.4	132.4	4.57	4.21	4.39
6 x 3	133.0	141.9	137.5	4.12	3.82	3.97
6 x 4	145.2	155.0	150.1	3.80	3.53	3.66
6 x 5	150.7	162.5	156.6	3.41	3.14	3.27
5 x 2	126.5	135.3	130.8	4.80	4.28	4.54
5 x 3	130.1	137.7	133.9	4.41	4.07	4.24
5 x 4	135.3	142.0	138.7	3.93	3.67	3.80
5 x 5	147.5	156.4	151.9	3.59	3.16	3.38
6 x 6	152.6	171.2	161.9	3.31	3.04	3.18
Mean	138.3	148.7		3.99	3.66	
	CD (0.05)			CD (0.05)		
	Spacing	10.9		Spacing	0.12	
	Pruning	5.2		Pruning	0.06	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

4.2.2 Tree height

The data presented in table 7 shows that tree height was significantly decreased with increasing the spacing and pruning levels. Tree height was significantly affected by the plant spacings. Among the different spacings, maximum (4.54 m) tree height was recorded in trees spaced at 5×2 m and minimum (3.18 m) was observed in trees spaced at 6×6 m. Tree height was significantly affected by the pruning treatments. In un-pruned trees mean tree height was recorded 3.99 m whereas, it was 3.66 m in pruned trees. The interaction between different spacing and pruning treatments was statistically found non significant.

4.2.3 Tree spread

Tree spread was significantly different among spacing and pruning treatments (Table 8). The data shows that tree spread significantly increased with the increasing spacing. Among the treatments tree spread was found significantly higher (4.75 m) in trees spaced at 6×6 m than all other trees spacings. Whereas, minimum (3.48) was recorded in trees spaced at 5×2 m. Tree spread was significantly affected by the pruning treatments. In un-pruned trees tree spread was recorded 4.26 m whereas, in pruned trees it was 3.83 m. The interaction between spacing and pruning was found statistically non significant.

4.2.4 Canopy volume (cm³)

The data presented in table 8 shows that all the treatments significantly affected the canopy volume. Among the treatments, maximum canopy volume (37.67 m³) was recorded in trees spaced at 6×5 m spacing which was at par with trees spaced at 6×5 m whereas, minimum (29.09 m³) was noticed in trees spaced at 6×2 m. Canopy volume also significantly affected by the pruning treatments. Mean canopy volume value was recorded 37.25 m³ in un-pruned trees whereas, in pruned trees it was observed 27.69 m³. The interaction effect between spacing and pruning for canopy volume was found statistically non significant.

Table 8: Effect of spacing and pruning on tree spread (m) and canopy volume (m³) of guava cv. Hisar safeda

Spacing (m)	Tree spread (m)			Canopy volume (m ³)		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	3.82	3.41	3.62	34.74	25.62	30.18
6 x 3	4.06	3.62	3.84	35.37	26.17	30.77
6 x 4	4.34	3.93	4.14	37.35	28.47	32.91
6 x 5	4.80	4.36	4.58	41.06	31.17	36.12
5 x 2	3.66	3.29	3.48	33.86	24.32	29.09
5 x 3	3.95	3.53	3.74	35.95	26.49	31.22
5 x 4	4.18	3.77	3.98	35.88	27.22	31.55
5 x 5	4.53	4.04	4.29	38.52	26.97	32.75
6 x 6	4.96	4.54	4.75	42.55	32.78	37.67
Mean	4.26	3.83		37.25	27.69	
	CD (0.05)			CD (0.05)		
	Spacing	0.14		Spacing	2.86	
	Pruning	0.07		Pruning	1.35	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

4.2.5 Shoot length

The data presented in table 9 shows that shoot length was significantly different among spacings and pruning treatments. Shoot length was significantly increased with the increasing spacing. Among the treatments, shoot length was found significantly higher (119.8 cm) in 5×6 m spacing than other 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m

spacings and minimum (93.2 cm) in 5×2 m spacing. The data also showed that shoot length was significantly affected by the pruning treatments. Mean shoot length 110.8 cm was recorded in pruned trees and in pruned trees it was observed 103.1 cm. The interaction between spacing and pruning was also found significant. Shoot length was recorded significantly higher 122.3 cm in wider spacing (6× 6 m) of pruned trees as compared to other spacings of pruned and un-pruned trees. Whereas, shoot length (88.6 cm) was noticed significantly lower in closer spacing (5×2 m) of un-pruned trees

Table 9: Effect of spacing and pruning on shoot length (cm) of guava cv. Hisar safeda

Spacing (m)	Shoot length (cm)		
	Pruning		
	Non pruned	Pruned	Mean
6 x 2	92.5	100.5	96.5
6 x 3	99.4	107.5	103.4
6 x 4	106.4	115.0	110.7
6 x 5	114.2	120.1	117.1
5 x 2	88.6	97.8	93.2
5 x 3	95.7	104.	99.9
5 x 4	103.3	112.0	107.6
5 x 5	109.9	118.0	114.0
6 x 6	117.3	122.3	119.8
Mean	103.1	110.8	
	CD (0.05) Spacing 0.8 Pruning 0.4 Spacing x Pruning 1.1		

4.2.6 Chlorophyll ‘a’ and ‘b’ content of the leaves

Data (Table 10) indicates that chlorophyll ‘a’ and ‘b’ content of leaves were significantly different among the spacings and pruning treatments during the rainy season. The chlorophyll ‘a’ content of leaves varied from 3.14 to 3.34 mg/g and chlorophyll ‘b’ content of leaves varied from 2.56 to 3.07 mg/g. The highest chlorophyll ‘a’ content (3.33 mg/g) was observed in 6×6 m spacing which was at par with 6× 5 m spacing and minimum (3.16 mg/g) in 5×2 m spacing. Maximum chlorophyll ‘b’ content (2.94 mg/g) was recorded in 6×6 m spacing which was at par with 6×5 m, 6×4 m, 6×3 m and 5×4 m spacing and minimum (270 mg/g) was recorded in 5×2 m spacing. Chlorophyll ‘a’ and ‘b’ content of leaves was also significantly affected by pruning treatments. In pruned trees chlorophyll “a” and chlorophyll ‘b’ were found 3.28mg/g and 2.92 mg/g, respectively whereas, in un-pruned trees chlorophyll ‘a’ and chlorophyll “b” content of leaves were observed 3.24 mg/g and 2.74 mg/g, respectively. The interaction effect of different spacing and pruning treatments on ‘a’ and ‘b’ content of leaves was statistically found non significant.

Table 10: Effect of spacing and pruning on chlorophyll 'a' and 'b' content (mg/g) during the rainy season leaf of guava cv. Hisar safeda

Spacing (m)	Chlorophyll '(a)'			Chlorophyll '(b)'		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	3.17	3.23	3.20	2.60	2.95	2.78
6 x 3	3.22	3.27	3.25	2.88	2.87	2.87
6 x 4	3.26	3.31	3.29	2.82	2.97	2.89
6 x 5	3.30	3.33	3.31	2.80	3.00	2.90
5 x 2	3.14	3.19	3.16	2.56	2.84	2.70
5 x 3	3.20	3.26	3.23	2.72	2.89	2.80
5 x 4	3.25	3.29	3.27	2.78	2.85	2.82
5 x 5	3.28	3.32	3.30	2.70	2.81	2.76
6 x 6	3.31	3.34	3.33	2.80	3.07	2.94
Mean	3.24	3.28		2.74	2.92	
	CD (0.05)			CD (0.05)		
	Spacing	0.02		Spacing	0.14	
	Pruning	0.01		Pruning	0.68	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

The perusal of data in table 11 indicates that chlorophyll 'a' and 'b' content of leaves were significantly increased with increasing the spacings and pruning levels during the winter season. The chlorophyll 'a' content of leaves varied from 3.02 to 3.31 mg/g and chlorophyll 'b' content varied from 2.23 to 2.87 mg/g. The highest chlorophyll (3.30 mg/g) content was recorded in 6×6 m spacing and minimum (3.07 mg/g) was observed in 5×2 m spacing. Maximum (2.77mg/g) chlorophyll 'b' content was observed in 6×6 m spacing which was at par with 6×4 m and 6×5 m and minimum (2.50 mg/g) was recorded in 5×2 m spacing. Pruning also significantly affected the chlorophyll 'a' and 'b' content of leaves during the winter season. The mean chlorophyll 'a' and chlorophyll 'b' content value recorded in pruned trees and un-pruned trees were 3.22 mg/g, 2.73 mg/g and 3.16 mg/g mg/g and 2.54 mg/g, respectively. The interaction between spacing and pruning treatments on chlorophyll 'a' was found non significant. The data showed that interaction between spacing and pruning treatments on chlorophyll 'b' content of leave was statistically found significant. Among the treatments highest chlorophyll 'b' content (2.87 mg/g) was recorded in wider spacing (6×6m) of pruned trees and minimum (2.23 mg/g) was recorded in closer spacing (5×2 m) of un-pruned trees.

Table 11: Effect of spacing and pruning on chlorophyll ‘a’ and ‘b’ content (mg/g) during the winter season leaf of guava cv. Hisar safeda

Spacing (m)	Chlorophyll ‘a’			Chlorophyll ‘b’		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	3.06	3.14	3.10	2.47	2.70	2.58
6 x 3	3.13	3.21	3.17	2.47	2.81	2.64
6 x 4	3.20	3.27	3.23	2.67	2.85	2.76
6 x 5	3.26	3.30	3.28	2.57	2.81	2.69
5 x 2	3.02	3.11	3.07	2.23	2.77	2.50
5 x 3	3.11	3.17	3.14	2.63	2.59	2.61
5 x 4	3.17	3.23	3.20	2.67	2.60	2.63
5 x 5	3.23	3.27	3.25	2.52	2.61	2.56
6 x 6	3.28	3.31	3.30	2.67	2.87	2.77
Mean	3.16	3.22		2.54	2.73	
	CD (0.05)			CD (0.05)		
	Spacing	0.02		Spacing	0.14	
	Pruning	0.01		Pruning	0.07	
	Spacing x Pruning	NS		Spacing x Pruning	0.20	

4.2.7 Leaf area

Data recorded and presented in table 12 shows that leaf area was significantly different among the spacings and pruning treatments during the rainy season. Leaf area significantly decreased with increasing the spacing. Among the treatments leaf area was found significantly higher (76.29 cm²) in 5×2 m spacing than all other spacings and minimum (68.34 cm²) was recorded in 6×6 m spacing. Leaf area was also significantly affected by pruning treatments. Leaf area was recorded in un-pruned and pruned trees 75.03 cm² and 70.13 cm², respectively. The interaction effect between spacing and pruning was found statistically non significant.

The observations on leaf area revealed that a significant variation exists among the different spacing and pruning treatments during the winter season (Table12). Leaf area significantly decreased with increasing the spacings. Among the treatments leaf area was found significantly higher (73.98 cm²) in closer spacing (5×2 m) as compared to all other spacings whereas, it was minimum (65.62 cm²) in wider spacing (6×6 m) trees. Leaf area was also significantly affected by pruning treatments. Leaf area recorded in un-pruned and pruned trees were 71.48 cm² and 67.75 cm², respectively. The interaction effect between spacing and pruning for leaf area was statistically found non significant.

Table 12: Effect of spacing and pruning on leaf area (cm²) of guava cv. Hisar safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	77.68	73.52	75.60	74.19	70.85	72.52
6 x 3	75.53	71.59	73.56	72.78	68.74	70.76
6 x 4	74.41	69.21	71.81	70.03	66.34	68.19
6 x 5	72.48	66.76	69.62	68.78	64.11	66.45
5 x 2	78.39	74.18	76.29	75.26	72.71	73.98
5 x 3	76.36	72.45	74.41	73.60	69.93	71.76
5 x 4	75.03	70.11	72.57	71.59	67.59	69.59
5 x 5	73.93	68.14	71.03	69.63	65.69	67.66
6 x 6	71.45	65.22	68.34	67.48	63.76	65.62
Mean	75.03	70.13		71.48	67.75	
	CD (0.05)			CD (0.05)		
	Spacing	1.01		Spacing	0.86	
	Pruning	0.05		Pruning	0.41	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

4.2.8 Leaf area index

A close perusal of data (Table 13) shows that the significant variation exists among the spacings and pruning treatments. Among the treatments leaf area index was found significantly higher (2.22) in 5×2 m spacing than all other spacings and minimum (1.10) was recorded in 6×6 m spacing. Leaf area index was also significantly affected by pruning. Leaf area index recorded in pruned and un-pruned trees were 1.69 and 1.52, respectively. The interaction effect between spacing and pruning for leaf area index was statistically also found significant. Maximum leaf area index (2.28) was noticed in closer spacing (5×2 m) of pruned trees as compared to all other spacings of pruned and un-pruned trees. While minimum leaf area index (0.98) was recorded in wider spacing (6×6 m) of un-pruned trees.

It was also observed that leaf area index was significantly different among the spacings and pruning treatments during the winter season. Leaf area index significantly decreased with the increasing spacings. Among the treatments leaf area index was found significantly higher (2.14) in closer spacing (5×2 m) as compared to all other spacings whereas, it was minimum (1.00) in wider spacing (6×6 m). The data shows that leaf area index also significantly affected by the pruning treatments. The leaf area index recorded in pruned and un-pruned trees were 1.61 and 1.45, respectively. The interaction effect between spacing and pruning was also found significant. Highest leaf area index (2.20) was noticed in closer spacing (5× 2 m) of pruned trees which is significantly higher as compared to all other spacings of pruned and un-pruned trees. Whereas minimum leaf area index (0.90) was recorded in wider spacing (6×6 m) of un-pruned trees.

Table 13: Effect of spacing and pruning on leaf area index of guava cv. Hisar safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	1.93	1.55	1.74	1.90	1.49	1.69
6 x 3	1.33	1.91	1.62	1.28	1.88	1.58
6 x 4	1.38	1.59	1.49	1.33	1.43	1.38
6 x 5	1.15	1.37	1.26	1.08	1.27	1.17
5 x 2	2.16	2.28	2.22	2.07	2.20	2.14
5 x 3	1.74	1.97	1.86	1.63	1.90	1.76
5 x 4	1.66	1.76	1.71	1.59	1.70	1.65
5 x 5	1.35	1.56	1.46	1.31	1.48	1.40
6 x 6	0.98	1.22	1.10	0.90	1.10	1.00
Mean	1.52	1.69		1.45	1.61	
	CD (0.05)			CD (0.05)		
	Spacing	0.02		Spacing	0.02	
	Pruning	0.01		Pruning	0.01	
	Spacing x Pruning	0.03		Spacing x Pruning	0.03	

4.3 Flower and fruit characters

4.3.1 Duration of flowering

Data recorded and presented in table 14 on duration of flowering of guava was not significantly affected by spacing treatments during the rainy season. However, it was significantly affected by the pruning treatments. Duration of flowering recorded in un-pruned and pruned trees were 32.8 days and 31.8 days, respectively. The interaction between different spacing and pruning treatments was statistically found non significant.

Duration of flowering was significantly different among the spacings and pruning treatments during the winter season. Duration of flowering significantly decreased with increasing the spacing. Among the treatments duration of flowering was recorded significantly maximum (44.2 days) in trees spaced at 5×2 m than all other trees spaced at 5×3 m, 5×5 m, 6×2 m, 6×3 m, 5×4 m, 6×4 m and 6×5 m and minimum (40.3 days) was recorded in trees spaced at 6×6 m. Duration of flowering was also significantly affected by the pruning treatments. Longest duration of flowering (43.1 days) was recorded in un-pruned trees and minimum (41.1 days) in pruned trees. The interaction between spacing and pruning treatments showed statistically non significant effect for duration of flowering.

Table 14: Effect of spacing and pruning on the duration of flowering (days) in guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	33.0	31.3	32.2	43.7	41.5	42.6
6 x 3	32.0	31.7	31.8	42.7	41.0	41.8
6 x 4	32.3	32.7	32.5	42.0	41.3	41.7
6 x 5	32.7	31.0	31.8	42.0	40.0	41.1
5 x 2	34.0	32.0	33.0	45.7	42.7	44.2
5 x 3	33.7	31.7	32.7	44.0	41.3	42.7
5 x 4	32.0	32.0	31.8	42.7	41.7	41.7
5 x 5	32.7	31.8	32.0	43.3	42.0	42.7
6 x 6	32.7	32.0	31.8	41.7	39.0	40.3
Mean	32.8	31.8		43.1	41.1	
	CD (0.05) Spacing NS Pruning 0.06 Spacing x Pruning NS			CD (0.05) Spacing 1.1 Pruning 0.05 Spacing x Pruning NS		

4.3.2 Date of full bloom

Date of full bloom was recorded different for all the spacings and pruning treatments during both the seasons (Table 15). Date of full bloom varied from 21st May 2016 to 28th May 2016 for rainy season crop. Full bloom was **shortly** earlier in un-pruned trees as compared to pruned trees. However during winter season the full bloom occurred between 14th Aug 2016 to 19th Aug 2016.

Table 15: Effect of spacing and pruning on the full bloom of guava cv. Hisar Safeda

Spacing (m)	Date of full bloom			
	Rainy season		Winter season	
	Pruning		Pruning	
	Non pruned	Pruned	Non pruned	Pruned
6 x 2	24-5-2016	28-5-2016	19-8-2016	17-8-2016
6 x 3	23-5-2016	27-5-2016	17-8-2016	16-8-2016
6 x 4	22-5-2016	27-5-2016	17-8-2016	15-8-2016
6 x 5	22-5-2016	25-5-2016	16-8-2016	14-8-2016
5 x 2	26-5-2016	28-5-2016	19-8-2016	17-8-2016
5 x 3	24-5-2016	28-5-2016	18-8-2016	16-8-2016
5 x 4	24-5-2016	27-5-2017	17-8-2016	15-8-2016
5 x 5	23-5-2016	27-5-2017	16-8-2016	15-8-2016
6 x 6	21-5-2016	25-5-2017	15-8-2016	14-8-2016

4.3.3 End of flowering

The data indicated in table 16 showed that the date of end of flowering varied from 21st May 2016 to 7th June 2016 during rainy season. End of flowering occurred early (21st May 2016) in 6×6 m spacing of un-pruned trees as compared to all other spacings and pruned trees and late end of flowering (7th June 2016) was recorded in 5×2 m spacing of pruned trees. However, during winter season the end of flowering occurred between 4th Oct 2016 to 13th Oct 2016. Early end of flowering (4th Oct 2016) was noticed in pruned trees spaced at 6×6 m and late end of flowering (13th Oct 2016) was recorded in un-pruned trees spaced at 5×2 m.

Table16: Effect of spacing and pruning on end of flowering in guava cv. Hisar safeda

Spacing (m)	Rainy season		Winter season	
	Pruning		Pruning	
	Non pruned	Pruned	Non pruned	Pruned
6 x 2	30-5-2016	6-6-2016	12-10-2016	8-10-2016
6 x 3	29-5-2016	5-6-2016	11-10-2016	7-10-2016
6 x 4	22-5-2016	4-6-2016	10-10-2016	6-10-2016
6 x 5	22-5-2016	3-6-2016	9-10-2016	5-10-2016
5 x 2	1-6-2016	7-6-2016	13-10-2016	9-10-2016
5 x 3	30-5-2016	6-6-2016	12-10-2016	7-10-2016
5 x 4	24-5-2016	4-6-2016	10-10-2016	7-10-2016
5 x 5	23-5-2016	3-6-2016	10-10-2016	5-10-2016
6 x 6	21-5-2016	2-6-2016	9-10-2016	4-10-2016

4.3.4 Flower bud density

The data pertaining to flower bud density presented in table 17 revealed that the flower bud density significantly affected by the plant spacings. Flower bud density was recorded significantly higher (22.5 flowers/m) in wider spacing (6×6 m) as compared to all other spacings. Whereas minimum (12.9 flowers/m) flower bud density was recorded in closer spacing (5×2 m). Flower bud density was also significantly affected by pruning treatments. Flower bud density 20.1 flowers/m was recorded in pruned trees whereas, 15.7 flowers/m flower bud density was observed in un-pruned trees. Flower bud density significantly affected by the different parts of tree canopy. The upper part of the tree canopy exhibited significantly higher flower bud density (21.2 flowers/m) than the middle and lower canopy part. The interaction between spacing and pruning was also found significant. Maximum (25.5 flowers/m) flower bud density was recorded in wider spacing (6×6 m) of un-pruned trees as compared to all other spacings of pruned and un-pruned trees and minimum (10.9 flowers/m) flower bud density was observed in closer spacing (5×2 m) of pruned trees. Interaction effect between spacing and canopy for flower bud density was found significant. Maximum flower bud density (25.5 flowers/m) was noticed in upper canopy part of wider spacing (6×6 m) trees as compared to other spacings of different canopy part. While

minimum flower bud density (10.4 flowers/m) was recorded in closer spacing (5×2 m) of lower canopy part. Interaction effect between pruning and canopy for flower bud density was also found significant. Flower bud density was found significantly higher (23.5 flowers/m) in upper canopy part of un-pruned trees as compared to middle and lower canopy part of non pruned and pruned trees. Whereas minimum flower bud density (12.8 flowers/m) was recorded in lower canopy part of pruned trees. The interaction among the spacing, pruning and canopy was also statistically found significant. Highest flower bud density (28.5 flowers/m) was recorded in upper canopy part of wider spacing (6×6 m) of un-pruned trees as compared other spacings of pruned and un-pruned different parts of tree canopy whereas it was minimum (8.9 flowers/m) in lower canopy part of closer spacing (5×2 m) trees.

The data in table 18 shows that the flower bud density was significantly affected by the plant spacings and pruning treatments during the winter season. Tree spaced at 6×6 m recorded significantly higher (14.6 flowers/m) flower bud density than tree spaced at 6×5 m, 6×4 m, 5×5 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m spacing and minimum (7.5 flowers/m) at 5×2 m. The effect of pruning was also found significant. Flower bud density 12.9 flowers/m recorded from pruned trees, whereas 9.6 flowers/m flower bud density observed in un-pruned trees. Flower bud density also significantly affected by the different parts of tree canopy. The flower bud density was recorded significantly higher (14.0 flowers/m) in upper parts of the tree canopy as compared to all other middle and lower canopy parts. Similarly, flower bud density was observed significantly higher (11.0 flowers/m) in middle part of canopy as compared (8.8 flowers/m) to lower canopy part. The interaction between spacing and pruning was also found significant. Highest (16.6 flowers/m) flower bud density was recorded in wider spacing (6×6 m) of pruned trees as compared to all other spacings of pruned and un-pruned trees and lowest (6.6 flowers/m) flower bud density was observed in closer spacing (5×2 m) of un-pruned trees. The interaction between spacing and canopy was statistically found significant. Maximum flower bud density (17.6 flowers/m) was observed in upper canopy part of wider spacing (6×6 m) trees as compared to all other spacings of different canopy part. Whereas, minimum flower bud density (5.6 flowers/m) was recorded in closer spacing (5×2 m) of lower canopy part. Interaction effect between pruning and canopy for flower bud density was also found significant. Flower bud density was noticed significantly higher (15.8 flowers/m) in upper canopy part of pruned trees as compared to all other canopy part of non pruned and pruned trees. Whereas, lowest flower bud density (7.5 flowers/m) was recorded in lower canopy part of un-pruned trees. The interaction among the spacing, pruning and canopy was also statistically found significant. Highest flower bud density (28.5 flowers/m) was recorded in upper canopy part of wider spacing of un-pruned trees as compared other spacings of pruned and un-pruned different parts of tree canopy. The

interaction among the spacing, pruning and canopy was showed non significant effect for flower bud density.

Table 17: Effect of spacing, pruning and the part of tree canopy on the flower bud density (Number of flower bud/meter shoot length) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning → Canopy → Spacing(m) ↓	Non pruned (Np)			Pruned (P)				
	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	20.6	17.1	13.9	15.9	13.0	10.7		
6 x 3	22.9	19.4	16.0	18.9	14.7	12.6		
6 x 4	23.9	20.4	17.5	20.3	15.7	13.3		
6 x 5	25.6	22.2	19.4	22.2	17.1	14.6		
5 x 2	18.3	14.3	12.0	13.6	10.2	8.9		
5 x 3	22.2	18.5	14.9	17.1	13.9	11.0		
5 x 4	24.2	20.2	16.1	19.7	15.6	12.8		
5 x 5	25.0	21.9	18.8	20.6	17.8	14.2		
6 x 6	28.5	25.4	22.6	22.5	19.1	16.9		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	17.2	13.2	15.2	6 x 2	18.3	15.1	12.3	15.2
6 x 3	19.4	15.4	17.4	6 x 3	20.9	17.0	14.3	17.4
6 x 4	20.6	16.4	18.5	6 x 4	22.1	18.0	15.4	18.5
6 x 5	22.4	17.9	20.2	6 x 5	23.9	19.6	17.0	20.2
5 x 2	14.9	10.9	12.9	5 x 2	16.0	12.2	10.4	12.9
5 x 3	18.5	14.0	16.3	5 x 3	19.7	16.2	12.9	16.3
5 x 4	20.1	16.0	18.1	5 x 4	21.9	17.9	14.5	18.1
5 x 5	21.9	17.5	19.7	5 x 5	22.8	19.8	16.5	19.7
6 x 6	25.5	19.5	22.5	6 x 6	25.5	22.3	19.7	22.5
Mean	20.1	15.7		Mean	21.2	17.6	14.8	
Pruning x Canopy (P x C)					CD (0.05)			
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
					Spacing			0.3
Non pruned	23.5	19.9	16.9	20.1	Pruning			0.2
Pruned	19.0	15.3	12.8	15.7	Canopy			0.2
Mean	21.2	17.6	14.8		Spacing x Pruning			0.5
					Spacing x Canopy			0.6
					Pruning x Canopy			0.3
					Spacing x Pruning x Canopy			0.8

Table 18: Effect of spacing, pruning and the part of tree canopy on the flower bud density (Number of flower bud/meter shoot length) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
	Upper	Middle	Lower	Upper	Middle	Lower		
Canopy → Spacing(m) ↓								
6 x 2	9.7	6.1	5.2	13.3	10.3	7.9		
6 x 3	11.0	8.5	6.6	15.2	12.5	9.3		
6 x 4	12.7	9.5	7.8	17.1	13.9	11.8		
6 x 5	15.2	11.8	9.9	18.8	15.4	11.9		
5 x 2	8.8	6.2	4.9	10.4	8.5	6.4		
5 x 3	10.9	8.7	6.9	14.6	11.2	8.1		
5 x 4	12.5	8.9	7.2	16.1	12.4	10.7		
5 x 5	13.6	10.9	8.9	16.9	13.6	10.8		
6 x 6	15.4	12.6	10.2	19.8	16.9	13.2		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	7.0	10.5	8.8	6 x 2	11.5	8.2	6.6	8.8
6 x 3	8.7	12.3	10.5	6 x 3	13.1	10.5	7.9	10.5
6 x 4	10.0	14.2	12.2	6 x 4	14.9	11.7	9.8	12.1
6 x 5	12.3	15.3	13.8	6 x 5	17.0	13.6	10.9	13.8
5 x 2	6.6	8.4	7.5	5 x 2	9.6	7.4	5.6	7.5
5 x 3	8.8	11.3	10.1	5 x 3	12.7	10.0	7.5	10.1
5 x 4	9.5	13.0	11.3	5 x 4	14.3	10.6	8.9	11.3
5 x 5	11.1	13.8	12.4	5 x 5	15.2	12.3	9.8	12.4
6 x 6	12.7	16.6	14.7	6 x 6	17.6	14.7	11.7	14.7
Mean	9.6	12.9		Mean	14.0	11.0	8.8	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	12.2	9.3	7.5	9.6	Spacing			0.4
Pruned	15.8	12.7	10.0	12.9	Pruning			0.2
Mean	14.0	11.0	8.8		Canopy			0.2
					Spacing x Pruning			0.5
					Spacing x Canopy			0.7
					Pruning x Canopy			0.3
					Spacing x Pruning x Canopy			NS

4.3.5 Fruit set

A close perusal of data shows the significant variation among the various spacing and pruning treatments for fruit set per cent (Table 19) during rainy season. Fruit per cent was significantly affected by the plant spacing. Fruit set per cent was found significantly higher (73.9%) in tree spaced at 6×6 m as compared to all other spacings and minimum (65.2%) was recorded in trees spaced at 5×2 m. The effect of pruning was also found significant for fruit

set per cent. The fruit set 70.9 per cent was recorded in un-pruned trees, whereas, 67.9 per cent fruit set observed in pruned trees. Fruit set also significantly affected by the different canopy parts. The upper part of the tree canopy exhibited significantly higher (72.2 %) fruit set per cent than the middle and lower canopy part. The interaction between spacing and pruning was also found significant. Highest fruit set (76.2%) was found in wider spacing of (6×6 m) un-pruned trees as compared to all other spacings of un-pruned and pruned trees. While lowest fruit set (63.9%) was recorded in closer spacing (5×2 m) of pruned trees. The interaction between spacing and canopy was also statistically found significant. Maximum fruit set (76.3%) was observed in upper canopy part of wider spacing trees (6×6 m) as compared to all other spacing of different canopy parts, whereas minimum fruit set (62.8%) was recorded in closer spacing (5×2 m) of lower canopy part. The interaction effect between pruning and canopy for fruit set was also found significant. Highest fruit set (73.9%) was noticed in upper canopy part of un-pruned trees whereas, lowest fruit set (65.5%) was observed in lower canopy part of pruned trees. The data showed that interaction among the spacing, pruning and canopy for fruit set was statistically found significant. Fruit set was found significantly higher (78.8%) in wider spacing (6×6 m) of upper part canopy of un-pruned trees as compared to other spacings of different canopy parts of pruned and un-pruned trees. While fruit set (61.6%) was observed significantly lesser in closer spacing (5×2 m) lower canopy part of pruned trees.

The perusal of data in table 20 clearly indicates that significant variation exists among the various treatments during the winter season. Fruit set was significantly affected by the plant spacings. Maximum (68.2%) fruit set per cent was found at 6×6 m spacing and minimum fruit set was (62.3%) observed at 5×2 m spacing. Fruit set was also significantly affected by the pruning treatments. The fruit set 67.1 per cent was recorded in un-pruned trees, whereas 63.0 per cent fruit set was observed in pruned trees. Fruit set also significantly affected by the different parts of tree canopy. Maximum fruit set per cent (67.4 %) was noticed in upper part of tree canopy as compared to middle and lower parts of the tree canopy and minimum fruit set (62.8%) was observed in lower part of tree canopy. The interaction between spacing and pruning was also found significant. Highest fruit set (71.3 %) was found in wider spacing of (6×6 m) un-pruned trees as compared to all other spacings of non pruned and pruned trees. While lowest fruit set (60.5 %) was recorded in closer spacing (5×2 m) of pruned trees. The interaction between spacing and canopy was also statistically found significant. Maximum fruit set (70.5 %) was observed in upper canopy part of wider spacing trees (6×6 m) as compared to all other spacing of different canopy parts, whereas minimum fruit set (60.1 %) was recorded in closer spacing (5×2 m) of lower canopy part. The interaction effect between pruning and canopy for fruit set was also found significant. Highest fruit set (69.6 %) was noticed in upper canopy part of un-pruned trees whereas lowest fruit set

(61.1 %) was observed in lower canopy part of pruned trees. The data showed that interaction among the spacing, pruning and canopy for fruit set was statistically found significant. Fruit set was found significantly higher (73.2%) in wider spacing (6×6 m) of upper part canopy of un-pruned trees as compared to other spacings of different canopy parts of pruned and un-pruned trees. Similarly, fruit set (58.4 %) was observed significantly lesser in closer spacing (5×2 m) lower canopy part of pruned trees.

Table 19: Effect of spacing, pruning and the part of tree canopy on the fruit set (%) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)									
Pruning →	Non pruned (Np)			Pruned (P)					
Canopy →	Upper	Middle	Lower	Upper	Middle	Lower			
Spacing(m) ↓									
6 x 2	71.6	67.6	65.0	67.5	64.9	63.1			
6 x 3	72.9	69.5	66.0	69.3	66.6	64.6			
6 x 4	74.7	72.2	69.8	71.9	68.9	66.6			
6 x 5	77.2	74.4	71.9	72.2	70.9	68.0			
5 x 2	68.7	66.5	64.1	66.7	63.5	61.6			
5 x 3	71.7	68.2	66.0	69.2	65.24	62.8			
5 x 4	73.6	68.9	66.8	72.3	68.0	65.7			
5 x 5	75.6	72.9	70.6	72.9	69.3	67.4			
6 x 6	78.8	75.9	73.9	73.7	71.3	69.6			
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)					
Pruning →	Non Pruned	Pruned	Mean (S)	Canopy →	Upper	Middle	Lower	Mean (S)	
Spacing(m) ↓					Spacing(m) ↓				
6 x 2	68.1	65.2	66.6	6 x 2	69.6	66.2	64.0	66.61	
6 x 3	69.5	66.8	68.1	6 x 3	71.1	68.1	65.3	68.2	
6 x 4	72.2	69.1	70.7	6 x 4	73.3	70.5	68.2	70.7	
6 x 5	74.5	70.2	72.3	6 x 5	74.7	72.3	70.0	72.3	
5 x 2	66.4	63.9	65.2	5 x 2	67.7	65.0	62.8	65.2	
5 x 3	68.7	65.7	67.2	5 x 3	70.4	66.7	64.4	67.2	
5 x 4	69.8	68.7	69.2	5 x 4	73.0	68.4	66.2	69.2	
5 x 5	73.0	69.9	71.5	5 x 5	74.2	71.1	69.0	71.5	
6 x 6	76.2	71.5	73.9	6 x 6	76.3	73.6	71.7	73.9	
Mean	70.9	67.9		Mean	72.2	69.1	66.9		
Pruning x Canopy (P x C)				CD (0.05)					
Canopy →	Upper	Middle	Lower	Mean					
Pruning ↓									
Non pruned	73.9	70.7	68.2	70.9	Spacing			0.3	
Pruned	70.6	67.5	65.5	67.9	Pruning			0.2	
Mean	72.3	69.1	66.8		Canopy			0.2	
					Spacing x Pruning			0.5	
					Spacing x Canopy			0.6	
					Pruning x Canopy			0.3	
					Spacing x Pruning x Canopy			0.8	

Table 20: Effect of spacing, pruning and the part of tree canopy on the fruit set (%) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)									
Pruning →	Non pruned (Np)			Pruned (P)					
	Upper	Middle	Lower	Upper	Middle	Lower			
Canopy →									
Spacing(m) ↓									
6 x 2	67.6	65.1	62.9	65.1	62.3	61.0			
6 x 3	70.2	67.5	65.4	66.1	63.3	61.7			
6 x 4	71.6	68.5	65.8	65.7	63.9	62.5			
6 x 5	73.2	69.1	66.6	65.1	62.6	61.0			
5 x 2	66.7	63.9	61.8	62.7	60.5	58.4			
5 x 3	68.7	66.4	64.9	64.6	61.8	61.1			
5 x 4	66.7	64.1	61.8	64.9	62.4	60.6			
5 x 5	68.9	66.5	63.2	65.1	62.5	61.0			
6 x 6	73.2	72.2	68.5	67.9	64.7	62.6			
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)					
Pruning →	Non Pruned	Pruned	Mean (S)	Canopy →	Upper	Middle	Lower	Mean (S)	
Spacing(m) ↓					Spacing(m) ↓				
6 x 2	65.2	62.8	64.0	6 x 2	66.3	63.7	61.9	64.0	
6 x 3	67.7	63.7	65.7	6 x 3	68.1	65.4	63.5	65.7	
6 x 4	68.6	64.0	66.3	6 x 4	68.6	66.2	64.1	66.3	
6 x 5	69.6	62.9	66.3	6 x 5	69.1	65.8	63.8	66.3	
5 x 2	64.1	60.5	62.3	5 x 2	64.7	62.2	60.1	62.3	
5 x 3	66.7	62.5	64.6	5 x 3	66.6	64.1	63.0	64.6	
5 x 4	64.2	62.6	63.4	5 x 4	65.8	63.2	61.2	63.4	
5 x 5	66.2	62.9	64.5	5 x 5	67.0	64.5	62.1	64.5	
6 x 6	71.3	65.0	68.2	6 x 6	70.5	68.4	65.6	68.2	
Mean	67.1	63.0		Mean	67.4	64.8	62.8		
Pruning x Canopy (P x C)				CD (0.05)					
Canopy →	Upper	Middle	Lower	Mean					
Pruning ↓									
Non pruned	69.6	67.0	64.5	67.1	Spacing			0.3	
Pruned	65.2	62.7	61.1	63.0	Pruning			0.1	
Mean	67.4	64.9	62.8		Canopy			0.2	
					Spacing x Pruning			0.4	
					Spacing x Canopy			0.5	
					Pruning x Canopy			0.2	
					Spacing x Pruning x Canopy			0.7	

4.3.6 Fruit retention

Fruit retention was found significantly higher (56.9%) in tree spaced at 6×6 m as compared to other trees spaced at 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m and minimum fruit retention (51.1%) was observed at 5×2 m spacing during the rainy season (Table 21). The effect of pruning was also found significant. The fruit retention of 56.4 per cent was recorded in pruned trees whereas, in un-pruned trees it was recorded 52.2 per cent. The fruit retention was also significantly affected by the different parts of tree canopy. The

upper part of the tree canopy exhibited significantly higher (56.9 %) fruit retention than the middle and lower canopy part. The interaction between spacing and pruning was also found significant. Highest fruit retention (59.5%) was recorded in wider spacing (6×6 m) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas lowest fruit retention (49.5%) was observed in closer spacing (5×2 m) of un-pruned trees. The interaction between spacing and canopy was also found significant. Maximum fruit retention (59.7 %) was observed in upper canopy part of wider spacing (6×6 m) trees as compared to all other spacings of different canopy part, whereas minimum fruit retention (48.8%) was recorded in closer spacing (5×2 m) of lower canopy part. The interaction between pruning and canopy as well as the interaction effect among the spacing, pruning and canopy was statistically found non significant.

The data shown in table 22 clearly indicates that fruit retention per cent significantly increased with increasing the spacings, pruning levels and parts of tree canopy during the winter season. Maximum fruit retention (58.2%) was found at 6×6 m spacing and minimum (53.3%) was observed at 5×2 m spacing. The fruit retention was also significantly affected by the pruning treatments. The fruit retention of 57.1 per cent was recorded in pruned trees, whereas, 54.6 per cent was observed in un-pruned trees. The fruit retention was significantly affected by the different parts of tree canopy. Maximum fruit retention (58.7%) was noticed in upper part of tree canopy as compared to middle and lower parts of the tree canopy and minimum fruit retention (53.2%) was observed in lower part of tree canopy. The interaction between spacing and pruning was also found significant. Highest fruit retention (59.9%) was found in wider spacing (6×6 m) of pruned trees as compared to all other spacings of un-pruned and pruned trees. While lowest fruit retention (52.6 %) was recorded in closer spacing (5×2 m) of un-pruned trees. The interaction between spacing and canopy was statistically found non significant. Irrespective of pruning the interaction effect between pruning and canopy for fruit retention was found significant. Highest fruit retention (59.9%) was noticed in upper canopy part of pruned trees whereas, lowest fruit retention (52.1 %) was observed in lower canopy part of un-pruned trees. The data showed that interaction among the spacing, pruning and canopy for fruit retention was also statistically found significant. The fruit retention was found significantly higher (62.2 %) in wider spacing (6×6 m) of upper canopy part of pruned trees as compared to other spacings of different canopy parts of pruned and un-pruned trees except 6×5 m upper part of pruned trees. Minimum fruit retention (50.1%) was observed in closer spacing (5×2 m) of lower canopy part of un-pruned trees.

Table 21: Effect of spacing, pruning and the part of tree canopy on the fruit retention (%) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	53.3	50.8	48.6	57.5	54.6	52.9		
6 x 3	54.1	51.7	49.3	58.4	55.4	52.8		
6 x 4	55.2	52.5	51.1	59.6	56.5	54.9		
6 x 5	55.9	53.0	50.6	61.2	58.4	55.7		
5 x 2	52.8	48.8	47.0	54.9	52.2	50.7		
5 x 3	54.3	51.4	49.4	57.9	55.4	53.1		
5 x 4	54.9	52.2	49.8	59.4	56.5	54.2		
5 x 5	56.1	52.6	50.4	60.2	57.5	54.5		
6 x 6	57.2	54.1	51.6	62.2	59.8	56.5		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	50.9	55.0	52.9	6 x 2	55.4	52.7	50.7	52.9
6 x 3	51.7	55.5	53.6	6 x 3	56.3	53.5	51.0	53.6
6 x 4	52.9	57.0	54.9	6 x 4	57.3	54.5	53.0	54.9
6 x 5	53.2	58.4	55.8	6 x 5	58.5	55.7	53.2	55.8
5 x 2	49.5	52.6	51.1	5 x 2	53.9	50.5	48.8	51.1
5 x 3	51.7	55.5	53.6	5 x 3	56.1	53.4	51.3	53.6
5 x 4	52.3	56.7	54.5	5 x 4	57.1	54.4	52.0	54.5
5 x 5	53.0	57.4	55.2	5 x 5	58.1	55.1	52.4	55.2
6 x 6	54.3	59.5	56.9	6 x 6	59.7	57.0	54.0	56.9
Mean	52.2	56.4		Mean	56.9	54.1	51.8	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning			0.3
Non pruned	54.9	51.9	49.7	52.2	Canopy			0.2
Pruned	59.0	56.3	53.9	56.4	Spacing x Pruning			0.2
Mean	56.9	54.1	51.8		Spacing x Canopy			0.5
					Pruning x Canopy			0.6
					Spacing x Pruning x Canopy			NS
								NS

Table 22: Effect of spacing, pruning and the part of tree canopy on the fruit retention (%) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	56.7	53.03	51.0	59.1	55.4	53.2		
6 x 3	57.3	53.35	51.4	58.5	56.6	53.5		
6 x 4	57.4	54.56	52.9	61.1	57.5	54.9		
6 x 5	58.9	55.4	53.1	61.7	59.5	56.5		
5 x 2	55.2	52.4	50.1	57.2	54.4	51.6		
5 x 3	56.9	53.3	51.4	57.9	55.4	53.1		
5 x 4	57.9	54.2	51.6	59.7	57.5	54.5		
5 x 5	58.4	55.4	53.2	61.3	58.0	54.9		
6 x 6	58.7	56.6	54.0	62.2	60.2	57.3		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	53.6	55.9	54.7	6 x 2	57.9	54.2	52.1	54.7
6 x 3	54.0	56.1	55.1	6 x 3	57.9	54.9	52.4	55.1
6 x 4	55.0	57.9	56.4	6 x 4	59.3	56.0	53.9	56.4
6 x 5	55.8	59.2	57.5	6 x 5	60.3	57.4	54.8	57.5
5 x 2	52.6	54.4	53.5	5 x 2	56.2	53.4	50.9	53.5
5 x 3	53.9	55.5	54.7	5 x 3	57.4	54.4	52.2	54.6
5 x 4	54.6	57.2	55.9	5 x 4	58.8	55.8	53.0	55.9
5 x 5	55.7	58.0	56.9	5 x 5	59.8	56.7	54.1	56.9
6 x 6	56.4	59.9	58.2	6 x 6	60.5	58.4	55.6	58.2
Mean	54.6	57.1		Mean	58.7	55.7	53.2	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing			0.3
Non pruned	57.5	54.2	52.1	54.6	Pruning			0.2
Pruned	59.9	57.2	54.4	57.1	Canopy			0.2
Mean	58.7	55.7	53.2		Spacing x Pruning			0.5
					Spacing x Canopy			NS
					Pruning x Canopy			0.3
					Spacing x Pruning x Canopy			0.8

4.3.7 Fruit drop

A close perusal of data shows the significant variation exists among the various treatments for fruit drop (Table 23) during the rainy season. Fruit drop was found significantly increased with increasing plant density. Fruit drop was found significantly higher (48.9 %) in trees spaced at 5× 2 m as compared to all other spacings and minimum (43.1%) was recorded in 6×6 m spacing. The fruit drop was also significantly affected by pruning treatments. The fruit drop was recorded 47.8 per cent in un-pruned trees whereas,

43.6 per cent fruit drop noticed in pruned trees. The fruit drop was significantly affected by the different parts of tree canopy. The lower part of the tree canopy exhibited significantly higher (48.2 %) fruit drop as compared to upper and middle canopy parts. The interaction between spacing and pruning was also found significant. Highest fruit drop (50.5%) was recorded in closer spacing (5×2 m) of un-pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas lowest fruit drop (40.5%) was recorded in wider spacing (6×6 m) of pruned trees. The interaction between spacing and canopy was also found significant. Maximum fruit drop (51.2%) was recorded in lower canopy part of closer spacing (5×2 m) trees as compared to all other spacings of different canopy part, whereas minimum fruit drop (40.3%) was recorded in wider spacing (6×6 m) of upper canopy part. The interaction between pruning and canopy was statistically found non significant. The data showed that interaction effect among the spacing, pruning and canopy on fruit drop was also statistically found non significant.

The data presented in table 24 shows that the fruit drop was also significantly affected by different spacing and pruning treatments during the winter season. Tree spaced at 5×2 m recorded significantly maximum (46.5%) fruit drop than all other spacings and minimum (41.9 %) was noticed at 5×2 m spacing. The fruit drop was also significantly affected by the pruning treatments. The fruit drop 45.4 per cent was recorded in un- pruned trees, whereas 42.9 per cent fruit drop was noticed in pruned trees. The fruit drop was also significantly affected by the different parts of tree canopy. Maximum fruit drop (46.8%) was noticed in lower part of tree canopy as compared to middle and upper parts of the tree canopy and minimum fruit drop (41.3%) was recorded in upper part of tree canopy. The interaction between spacing and pruning was also found significant. Highest fruit drop (47.4 %) was found in closer spacing (5×2 m) of un-pruned trees as compared to all other spacings of un-pruned and pruned trees. While lowest fruit drop (40.1%) was recorded in wider spacing (6×6 m) of pruned trees. The interaction between spacing and canopy was statistically found non significant. Irrespective of pruning the interaction effect between pruning and canopy for fruit drop was found significant. Highest fruit drop (47.9%) was noticed in lower canopy part of un-pruned trees whereas lowest fruit drop (40.1 %) was recorded in upper canopy part of pruned trees. The data showed that interaction among the spacing, pruning and canopy for fruit drop was also statistically found significant. The fruit drop was found significantly higher (49.9 %) in closer spacing (5×2 m) of lower canopy part of un-pruned trees as compared to all other spacings of different canopy parts of pruned and un-pruned trees. Least fruit drop (37.7%) was recorded in wider spacing (6×6 m) of upper canopy part of pruned trees.

Table 23: Effect of spacing, pruning and the part of tree canopy on the fruit drop (%) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	46.7	49.2	51.4	42.5	45.4	47.1		
6 x 3	45.9	48.4	50.7	41.6	44.6	47.2		
6 x 4	44.9	47.5	48.9	40.2	43.5	45.1		
6 x 5	44.1	47.0	49.4	38.8	41.6	44.3		
5 x 2	47.2	51.2	53.0	45.1	47.8	49.3		
5 x 3	45.7	48.6	50.6	42.1	44.5	46.9		
5 x 4	45.1	47.8	50.2	40.6	43.5	45.8		
5 x 5	43.9	47.4	49.6	39.8	42.5	45.5		
6 x 6	42.8	45.9	48.2	37.8	40.1	43.5		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	49.1	45.0	47.1	6 x 2	44.6	47.3	49.3	47.1
6 x 3	48.3	44.5	46.4	6 x 3	43.7	46.5	49.0	46.4
6 x 4	47.1	43.0	45.1	6 x 4	42.6	45.5	47.0	45.1
6 x 5	46.8	41.6	44.2	6 x 5	41.5	44.3	46.8	44.2
5 x 2	50.5	47.4	48.9	5 x 2	46.1	49.5	51.2	48.9
5 x 3	48.3	44.5	46.4	5 x 3	43.9	46.6	48.7	46.4
5 x 4	47.7	43.3	45.5	5 x 4	42.9	45.6	48.0	45.5
5 x 5	45	42.6	44.8	5 x 5	41.9	44.9	47.6	44.8
6 x 6	45.7	40.5	43.1	6 x 6	40.3	43.0	46.0	43.1
Mean	47.8	43.6		Mean	43.1	45.9	48.2	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	45.1	48.1	50.2	47.8	Spacing			0.3
Pruned	41.0	43.7	46.1	43.6	Pruning			0.2
Mean	43.1	45.9	48.2		Canopy			0.2
					Spacing x Pruning			0.5
					Spacing x Canopy			0.6
					Pruning x Canopy			NS
					Spacing x Pruning x Canopy			NS

Table 24: Effect of spacing, pruning and the part of tree canopy on the fruit drop (%) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)									
Pruning →	Non pruned (Np)			Pruned (P)					
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower			
6 x 2	43.3	47.0	49.0	40.9	44.6	46.8			
6 x 3	42.7	46.7	48.6	41.5	43.5	46.5			
6 x 4	42.6	45.4	47.1	38.9	42.5	45.1			
6 x 5	41.1	44.6	46.9	38.5	40.5	43.5			
5 x 2	44.8	47.6	49.9	42.8	45.6	48.4			
5 x 3	43.1	46.7	48.6	42.1	44.6	46.9			
5 x 4	42.1	45.8	48.4	40.3	42.5	45.5			
5 x 5	41.6	44.6	46.8	38.7	42.0	45.1			
6 x 6	41.3	43.5	46.0	37.7	39.8	42.7			
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)					
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)	
6 x 2	46.4	44.1	45.3	6 x 2	42.1	45.8	47.9	45.3	
6 x 3	46.0	43.8	44.9	6 x 3	42.1	45.1	47.6	44.9	
6 x 4	45.0	42.2	43.6	6 x 4	40.7	44.0	46.1	43.6	
6 x 5	44.2	40.8	42.5	6 x 5	39.7	42.6	45.2	42.5	
5 x 2	47.4	45.6	46.5	5 x 2	43.8	46.6	49.1	46.5	
5 x 3	46.1	44.5	45.3	5 x 3	42.6	45.6	47.8	45.3	
5 x 4	45.4	42.8	44.1	5 x 4	41.2	44.2	47.0	44.1	
5 x 5	44.3	42.0	43.13	5 x 5	40.2	43.3	45.9	43.1	
6 x 6	43.6	40.1	41.9	6 x 6	39.5	41.6	44.4	41.9	
Mean	45.4	42.9		Mean	41.3	44.3	46.8		
Pruning x Canopy (P x C)				CD (0.05)					
Canopy → Pruning ↓	Upper	Middle	Lower	Mean					
Non pruned	42.5	45.7	47.9	45.4	Spacing				0.3
Pruned	40.1	42.8	45.6	42.9	Pruning				0.2
Mean	41.3	44.3	46.8		Canopy				0.2
					Spacing x Pruning				0.5
					Spacing x Canopy				NS
					Pruning x Canopy				0.3
					Spacing x Pruning x Canopy				0.8

4.4 Fruit yield

4.4.1 Number of fruits per tree

The data on number of fruits per plant counted before harvesting during the rainy and winter season presented in table 25.

Data shows that the number of fruits per tree significantly affected by different spacing and pruning treatments during the rainy season. Number of fruits per tree significantly increased with increasing plant spacing. Maximum (566.3) mean fruits per tree were harvested from trees spaced at 6×6 m spacing which was significantly higher than the number of fruits harvested from the trees planted at all other spacings and minimum (414.7)

was recorded in trees spaced at 5×2 m. The effect of pruning was also found significant. Un-pruned trees having (550.9) number of fruits per tree whereas, pruned trees having 408.8 number of fruits per tree. The interaction between spacing and pruning treatments was statistically found significant. Maximum number of fruits per tree (640.7) was recorded in wider spacing (6×6 m) of un-pruned trees, minimum (352.0) were found in closer spacing of pruned trees.

Data related to number of fruits per tree during winter season are presented in Table 25. Number of fruits per tree was found inversely related to plant density. Maximum (455.8) mean number of fruits per tree were harvested from trees spaced at 6×6 m which was significantly higher than the number of fruits harvested from the trees spaced at 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m and minimum (316.5) was harvested from trees spaced at 5×2 m. Pruning also significantly affected the number of fruits per tree. 433.9 number of fruits per tree was recorded in pruning treatments and 331.7 number of fruits per tree recorded in no pruning treatments. The interaction between spacing and pruning treatments was found non significant.

Table 25: Effect of spacing and pruning on the number of fruits per plant in guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	501.7	368.0	434.8	281.7	383.7	332.7
6 x 3	536.7	393.3	465.0	310.3	411.0	360.7
6 x 4	563.0	414.3	488.7	347.7	453.0	400.3
6 x 5	596.0	451.0	523.5	390.7	484.0	437.3
5 x 2	477.3	352.0	414.7	257.7	375.3	316.5
5 x 3	513.0	381.7	447.3	294.7	391.7	343.3
5 x 4	550.3	407.0	478.7	329.3	430.0	379.7
5 x 5	579.7	420.3	500.0	363.3	474.0	418.7
6 x 6	640.7	491.9	566.3	409.7	502.0	455.8
Mean	550.9	408.8		331.7	433.9	
	CD (0.05)			CD (0.05)		
	Spacing	9.8		Spacing	8.6	
	Pruning	4.6		Pruning	4.1	
	Spacing x Pruning	13.8		Spacing x Pruning	NS	

4.4.2 Fruit weight

A close perusal of data shows the significant variation exists among the various treatments for fruit weight (Table 26) during the rainy season. Maximum mean fruit weight (100.4 g) was recorded in fruits harvested from trees spaced at 6×6 m spacing and it was significantly more than the fruits harvested from all other trees spacings and minimum (85.2

g) at 5×2 m spacing. The fruit weight was also significantly affected by pruning treatments. Fruit weight significantly increased with increasing the pruning level. The average fruit weight 98.6 g was recorded of fruits harvested from pruned trees whereas, 88.3 g fruit weight noticed of fruits harvested from un-pruned trees. The fruit weight was also significantly affected by the different parts of tree canopy. The fruit weight was recorded significantly higher (97.2 g) in upper parts of the tree canopy as compared to middle and lower canopy parts. Similarly, fruit weight was observed significantly higher (93.6 g) in middle part of canopy as compared (89.5 g) to lower canopy part. The interaction between spacing and pruning was also found significant. Highest fruit weight (105.2g) was recorded in wider spacing (6×6 m) of pruned trees as compared to all other spacings of pruned and un-pruned trees and lowest fruit weight (79.3g) was observed in closer spacing (5×2 m) of un-pruned trees. The interaction effect between spacing and canopy for fruit weight was statistically found significant. Highest fruit weight (104.4 g) was observed in upper canopy part of wider spacing (6×6 m) trees as compared to all other spacings of different canopy part. Whereas, lowest fruit weight (81.3g) was recorded in closer spacing (5×2 m) of lower canopy part. Interaction effect between pruning and canopy for fruit weight was statistically found non significant. The interaction among the spacing, pruning and canopy was statistically found significant. Highest fruit weight (109.9g) was recorded in upper canopy part of wider (6×6 m) spacing of pruned trees as compared to all other treatments. While lowest fruit weight (74.2 g) was observed in closer spacing (5×2 m) of lower canopy part of un-pruned trees.

The data presented in table 27 indicates that all the treatments significantly different among the various treatments in their fruit weight during the winter season. The fruit weight was significantly affected by the plant spacings. Maximum fruit weight (110.4 g) was recorded of fruits harvested from trees spaced at 6×6 m and minimum (93.0g) at 5×2 m spacing. The fruit weight was also significantly affected by the pruning treatments. Fruit weight of 104.8 g was recorded of fruits harvested from pruned trees and, 96.2 g of fruits harvested from un-pruned trees. The interaction between spacing and pruning was also statistically found significant. The mean fruit weight 104.8 g was recorded of fruits harvested from pruned trees whereas 96.2 g fruit weight was noticed of fruits harvested from un-pruned trees. The fruit weight was also significantly affected by the different parts of tree canopy. The fruit weight was recorded significantly higher (104.1 g) in upper part of the tree canopy as compared middle and lower part of tree canopy. The interaction between spacing and pruning was also found significant. Highest fruit weight (114.5g) was noticed in wider spacing (6×6 m) of pruned trees as compared to all other spacings of pruned and un-pruned trees and lowest fruit weight (89.3 g) was recorded in closer spacing (5×2 m) of un-pruned trees.

Table 26: Effect of spacing, pruning and the part of tree canopy on the fruit weight (g) during the rainy season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	87.2	83.6	78.3	98.9	94.9	90.9		
6 x 3	89.2	86.6	81.4	100.7	97.2	93.9		
6 x 4	93.2	90.7	86.4	103.9	98.8	96.9		
6 x 5	98.0	93.3	90.5	107.6	104.8	98.4		
5 x 2	84.8	78.9	74.2	93.4	91.5	88.3		
5 x 3	88.6	85.6	79.9	99.9	96.9	92.5		
5 x 4	93.2	88.5	86.3	102.0	98.6	95.2		
5 x 5	95.4	92.4	90.2	104.5	100.6	96.8		
6 x 6	98.8	95.5	92.7	109.9	106.8	98.9		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	83.1	94.9	89.0	6 x 2	93.0	89.2	84.6	89.0
6 x 3	85.7	97.3	91.4	6 x 3	95.0	91.9	87.6	91.5
6 x 4	90.1	99.9	95.0	6 x 4	98.5	94.8	91.6	95.0
6 x 5	93.9	103.6	98.7	6 x 5	102.8	99.0	94.4	98.8
5 x 2	79.3	91.2	85.2	5 x 2	89.3	85.2	81.3	85.2
5 x 3	84.7	96.4	90.5	5 x 3	94.2	91.2	86.2	90.5
5 x 4	89.3	98.6	94.0	5 x 4	97.6	93.6	90.7	94.0
5 x 5	92.7	100.6	96.7	5 x 5	100.0	96.5	93.5	96.7
6 x 6	95.7	105.2	100.4	6 x 6	104.4	101.2	95.8	100.4
Mean	88.3	98.6		Mean	97.2	93.6	89.5	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	92.1	88.3	84.4	88.3	Spacing			0.3
Pruned	102.3	98.9	94.6	98.6	Pruning			0.1
Mean	97.2	93.6	89.5		Canopy			0.2
					Spacing x Pruning			0.4
					Spacing x Canopy			0.4
					Pruning x Canopy			NS
					Spacing x Pruning x Canopy			0.7

The interaction effect between spacing and canopy for fruit weight was also statistically found significant. Maximum fruit weight (114.0 g) was observed in upper canopy part of wider spacing (6 × 6 m) trees as compared to all other spacings of different canopy part whereas minimum fruit weight (89.8 g) was recorded in closer spacing (5×2 m) of lower canopy part. Interaction effect between pruning and canopy for fruit weight was statistically found significant. Maximum fruit weight (100.7 g) was observed in upper canopy part of pruned trees as compared to all other parts of canopy of pruned and un-pruned trees, whereas, minimum fruit weight (92.8 g) was recorded in lower canopy part of un-pruned trees. The interaction among the spacing, pruning and canopy showed statistically significant effect for

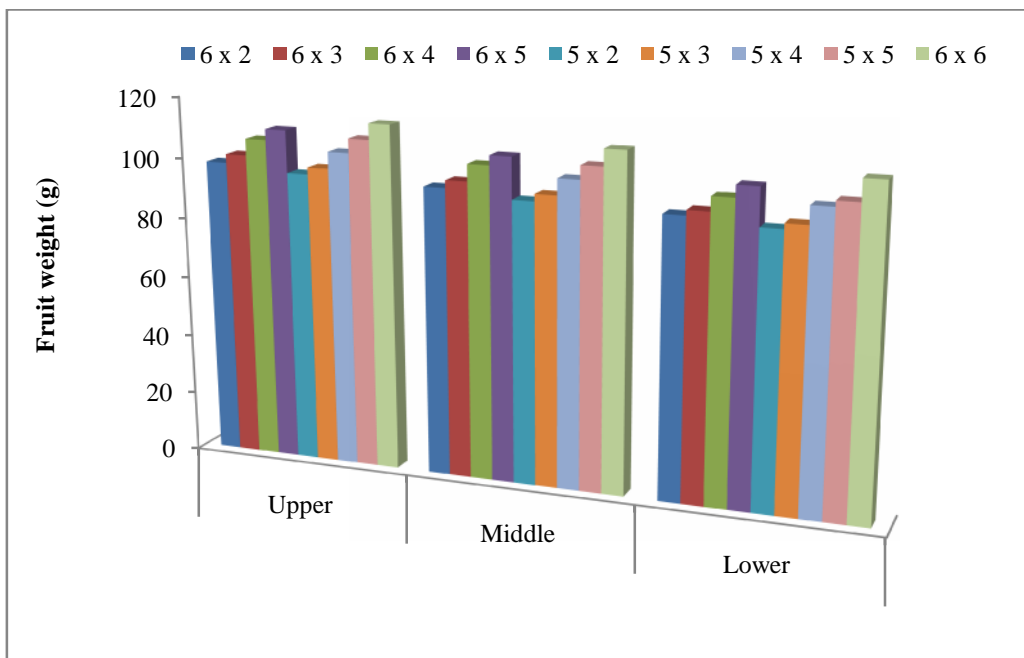
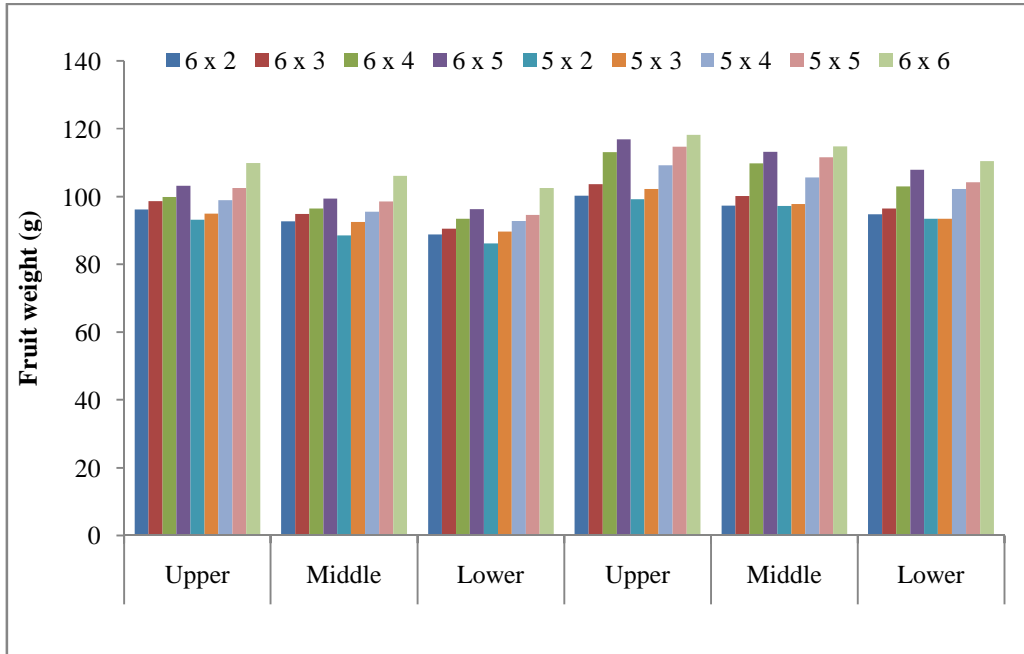


Fig. 5: Effect of spacing, pruning and the part of tree canopy on the fruit weight (g) during the winter season in guava cv. Hisar Safeda

fruit weight. Highest fruit weight (118.2 g) was recorded in upper canopy part of wider (6×6 m) spacing of pruned trees as compared other spacings of pruned and un-pruned different parts of tree canopy. While lowest fruit weight (86.2 g) was observed in closer spacing (5×2 m) of lower canopy part of un-pruned trees.

Table 27: Effect of spacing, pruning and the part of tree canopy on the fruit weight (g) during the winter season in guava cv. Hisar Safeda

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	96.2	92.7	88.8	100.3	97.3	94.7		
6 x 3	98.6	94.8	90.5	103.7	100.2	96.5		
6 x 4	99.9	96.5	93.5	113.1	109.8	103.0		
6 x 5	103.2	99.4	96.3	116.9	113.2	107.9		
5 x 2	93.2	88.5	86.2	99.2	97.2	93.5		
5 x 3	94.9	92.5	89.7	102.2	97.8	93.5		
5 x 4	98.9	95.5	92.8	109.2	105.6	102.2		
5 x 5	102.5	98.5	94.6	114.7	111.6	104.2		
6 x 6	109.9	106.1	102.5	118.2	114.8	110.5		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	92.6	97.4	95.0	6 x 2	98.2	95.0	91.8	95.0
6 x 3	94.7	100.1	97.4	6 x 3	101.1	97.5	93.5	97.4
6 x 4	96.6	108.6	102.6	6 x 4	106.5	103.1	98.2	102.6
6 x 5	99.7	112.6	106.2	6 x 5	110.1	106.3	102.1	106.2
5 x 2	89.3	96.6	92.9	5 x 2	96.2	92.8	89.8	92.9
5 x 3	92.3	97.9	95.1	5 x 3	98.5	95.1	91.6	95.1
5 x 4	95.7	105.7	100.7	5 x 4	104.0	100.5	97.5	100.7
5 x 5	98.5	110.2	104.4	5 x 5	108.7	105.0	99.4	104.4
6 x 6	106.2	114.5	110.3	6 x 6	114.0	110.5	106.5	110.3
Mean	96.2	104.8		Mean	104.1	100.7	96.7	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	99.7	96.1	92.8	96.2	Spacing			0.3
Pruned	108.6	105.3	100.7	104.8	Pruning			0.2
Mean	104.1	100.7	96.7		Canopy			0.2
					Spacing x Pruning			0.5
					Spacing x Canopy			0.6
					Pruning x Canopy			0.3
					Spacing x Pruning x Canopy			0.8

4.4.3 Fruit size

The data related to fruit size (fruit length and breadth) during the rainy season referred in table 28 revealed that fruit length and breadth were significantly different among the various treatments. The fruit length varied from 5.10 to 5.73 cm and fruit breadth varied from 4.99 to 5.61 cm. The highest mean fruit length (5.61cm) and mean fruit breadth

(5.51cm) were observed in trees spaced at 6×6m and minimum mean fruit length (5.20 cm) and mean fruit breadth (5.06 cm) was recorded at 5×2 m spacing. Fruit size significantly increased with increasing pruning levels. The value of mean fruit length 5.50 cm and mean fruit breadth 5.39 were obtained from pruned trees and mean fruit length 5.20 cm and mean breadth 5.06 cm were obtained from un-pruned trees. The interaction between different spacing and pruning treatments for fruit length and breadth was found non significant.

Table 28: Effect of spacing and pruning on the fruit size (cm) of guava cv. Hisar Safeda during the rainy season

Spacing (m)	Fruit length			Fruit breadth		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	5.24	5.40	5.32	5.18	5.32	5.25
6 x 3	5.35	5.45	5.40	5.19	5.30	5.25
6 x 4	5.40	5.54	5.47	5.28	5.43	5.36
6 x 5	5.46	5.61	5.53	5.36	5.52	5.44
5 x 2	5.10	5.30	5.20	4.99	5.14	5.06
5 x 3	5.30	5.42	5.36	5.21	5.37	5.29
5 x 4	5.39	5.48	5.43	5.26	5.38	5.32
5 x 5	5.42	5.59	5.51	5.33	5.47	5.40
6 x 6	5.49	5.73	5.61	5.41	5.61	5.51
Mean	5.35	5.50		5.25	5.39	
	CD (0.05)			CD (0.05)		
	Spacing	0.07		Spacing	0.07	
	Pruning	0.04		Pruning	0.03	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

Fruit size (fruit length and breadth) was also found significantly different among the various treatments and interactions during the winter season (Table 29). The fruit length varied from 5.25 to 5.84 cm and fruit breadth varied from 5.19 to 5.74 cm. Maximum mean fruit length (5.71cm) and mean fruit breadth (5.63cm) were recorded significantly higher in trees spaced at 6×6 m than all other spacings and minimum mean fruit length (5.32 cm) and mean fruit breadth (5.23 cm) at 5×2 m. Fruit size also significantly increased with increasing pruning levels. The average fruit length 5.59 cm and mean fruit breadth 5.49 were recorded in fruits harvested from pruned trees and average fruit length 5.45 cm and mean breadth 5.36 cm were observed in fruits harvested from un-pruned trees. The interaction between different spacing and pruning treatments for fruit length and breadth was found statistically significant. Maximum fruit length (5.84 cm) and fruit breadth (5.74) were recorded in wider spacing (6×2 m) of pruned trees as compared to all other spacing of pruned and un-pruned trees. Whereas minimum fruit length (5.25 cm) and fruit breadth (5.19 cm) was observed in closer spacing (5×2 m) of un-pruned trees.

Table 29: Effect of spacing and pruning on the fruit size (cm) of guava cv. Hisar Safeda during the winter season

Spacing (m)	Fruit length			Fruit breadth		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	5.34	5.49	5.41	5.23	5.39	5.31
6 x 3	5.45	5.53	5.49	5.36	5.44	5.40
6 x 4	5.49	5.60	5.55	5.38	5.52	5.45
6 x 5	5.54	5.69	5.62	5.40	5.59	5.50
5 x 2	5.25	5.39	5.32	5.19	5.26	5.23
5 x 3	5.41	5.52	5.47	5.36	5.41	5.39
5 x 4	5.48	5.59	5.54	5.37	5.49	5.43
5 x 5	5.50	5.63	5.56	5.44	5.55	5.50
6 x 6	5.57	5.84	5.71	5.52	5.74	5.63
Mean	5.45	5.59		5.36	5.49	
	CD (0.05) Spacing 0.05 Pruning 0.02 Spacing x Pruning 0.07			CD (0.05) Spacing 0.05 Pruning 0.02 Spacing x Pruning 0.07		

4.4.4 Yield per tree

A perusal of data given in table 30 indicates that fruit yield per tree increased with the increasing spacing and decreasing the pruning levels during the rainy season. Fruit yield per tree significantly affected by the plant spacings. Maximum (56.5 kg) yield per tree was recorded from trees spaced at 6×6 m and it was found significantly higher than the trees spaced at 6×5m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m and minimum (35.0 kg) was noticed in trees spaced at 5×2 m. The fruit yield per tree was also significantly affected by the pruning treatments. 48.9 kg fruit yield was recorded from un-pruned trees whereas, 40.5 kg fruit yield from pruned trees. The interaction between the spacing and pruning was also found significant. Highest fruit yield (61.3 kg) was noticed in wider spacing (6×6 m) of un-pruned trees as compared to all other spacings of pruned and un-pruned trees whereas, lowest fruit yield (32.1 kg) was recorded in closer spacing (5×2 m) of pruned trees.

It was observed that fruit yield significantly increased with increasing the spacings and pruning levels during the winter season (Table 30). Fruit yield per tree significantly affected by the plant spacings. Highest (50.5 kg) fruit yield per tree recorded from trees spaced at 6×6 m and it was found significantly more than yield from the trees spaced at ×5m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3m, 6×2m and minimum (29.6 kg) at 5×2 spacing. The fruit yield per tree was also significantly affected by the pruning treatments. 45.8 kg fruit yield per tree was recorded from pruned trees whereas, 32.1 kg fruit yield per tree from pruned trees. The interaction between the spacing and pruning was also found significant. Highest fruit

yield per tree (57.5 kg) was noticed in wider spacing (6×6 m) of pruned trees which is significantly higher as compared to all other spacings of pruned and un-pruned trees whereas, lowest fruit yield (23.0 kg) was recorded in closer spacing (5×2 m) of un-pruned trees.

Table 30: Effect of spacing and pruning on the fruit yield per tree (kg) of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	41.6	34.9	38.3	26.1	37.4	31.7
6 x 3	46.0	38.2	42.1	29.4	41.1	35.3
6 x 4	50.7	41.4	46.0	33.6	49.2	41.4
6 x 5	56.0	46.7	51.3	39.0	54.5	46.7
5 x 2	37.9	32.1	35.0	23.0	36.3	29.6
5 x 3	43.5	36.8	40.1	27.2	38.4	32.8
5 x 4	49.2	40.1	44.7	31.5	45.4	38.5
5 x 5	53.7	42.3	48.0	35.8	52.2	44.0
6 x 6	61.3	51.8	56.5	43.5	57.5	50.5
Mean	48.9	40.5		32.1	45.8	
	CD (0.05)			CD (0.05)		
	Spacing	1.0		Spacing	1.1	
	Pruning	0.5		Pruning	0.5	
	Spacing x Pruning	1.3		Spacing x Pruning	1.6	

4.4.5 Yield per hectare

The data presented in table 31 clearly indicates that fruit yield per hectare significantly increased with increasing the plant density during the rainy season. Maximum fruit yield per hectare (35.0 tonnes) was obtained from the closer spaced trees at 5×2 m and it was found significantly more than the yield obtained from the trees spaced at 6×2 m, 5×3 m, 6×3 m, 5×4 m, 6×4 m, 5×5m, 6×5m whereas, minimum fruit yield per hectare (15.7 tonnes) recorded from the wider spaced trees at 6×6 m. The fruit yield per hectare was also significantly affected by the pruning treatments. Fruit yield per hectare (25.5 tonnes) was recorded in un-pruned trees whereas, in pruned trees it was found (21.2 tonnes). The interaction effect between spacing and pruning for yield (per hectare) was found significant. The fruit yield per hectare was found significantly higher (37.9 tones) in closer spacing (5×2 m) of un-pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas, minimum (21.2 tonnes) was recorded in wider spacing (6×6 m) of pruned trees.

Table 31: Effect of spacing and pruning on the fruit yield per hectare (tonnes) of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	34.7	29.1	31.9	21.7	31.1	26.4
6 x 3	25.5	21.2	23.4	16.3	22.8	19.6
6 x 4	21.1	17.2	19.1	14.0	20.5	17.2
6 x 5	18.6	15.6	17.1	13.0	18.1	15.6
5 x 2	37.9	32.1	35.0	23.0	36.3	29.6
5 x 3	28.9	24.5	26.7	18.1	25.5	21.8
5 x 4	24.6	20.1	22.3	15.8	22.7	19.2
5 x 5	21.5	16.9	19.2	18.1	14.3	16.2
6 x 6	17.0	14.3	15.7	12.1	15.9	14.0
Mean	25.5	21.2		16.9	23.0	
	CD (0.05) Spacing 0.6 Pruning 0.3 Spacing x Pruning 0.9			CD (0.05) Spacing 0.7 Pruning 0.3 Spacing x Pruning 0.9		

Fruit yield per hectare significantly increased with increasing the plant density and pruning levels during the winter season (Table 31). Maximum fruit yield per hectare (29.6 tonnes) was recorded from trees spaced at 5×2 m and it was found significantly higher than yield obtained from the trees spaced at 6 × 2 m, 5× 3 m, 6×3 m, 5×4 m, 6×4 m, 5×5m, 6×5m whereas minimum yield per hectare (14.0 tonnes) was obtained from the trees spaced at 6×6 m. The yield per hectare was also significantly affected by the pruning treatments. Yield per hectare (23.0 tonnes) was recorded in pruned trees whereas, in un-pruned trees it was found (16.9 tonnes). The interaction effect between spacing and pruning for yield per hectare was found significant. The fruit yield per hectare was found significantly higher (36.3 tonnes) in closer spacing (5×2 m) of pruned trees as compared to all other spacings of pruned and un-pruned trees whereas, minimum (21.1 tonnes) was recorded in wider spacing (6×6 m) of un-pruned trees.

4.4.6 Fruiting density

Data on fruiting density are presented in table 32. It is clear from the data that the fruiting density was non significantly affected by the various treatments during the rainy season. However, maximum fruit density (15.7 fruits/ m³) was recorded in trees spaced at 6×6 m of un-pruned trees and minimum (14.1 fruits/ m³) was recorded in trees spaced at 5×4 m of pruned trees.

Table 32: Effect of spacing and pruning on the fruiting density (number/m³) of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	14.5	14.4	14.5	8.1	15.0	11.6
6 x 3	15.2	15.1	15.1	8.8	15.7	12.3
6 x 4	15.1	14.6	14.8	9.3	15.9	12.6
6 x 5	14.6	14.5	14.5	9.6	15.5	12.5
5 x 2	14.7	14.6	14.6	7.9	15.6	11.7
5 x 3	14.3	14.5	14.4	8.2	14.9	11.5
5 x 4	15.4	14.1	15.2	9.2	15.8	12.5
5 x 5	15.1	15.6	15.3	9.5	15.5	12.5
6 x 6	15.7	15.1	15.4	9.6	15.4	12.5
Mean	14.9	14.7		8.9	15.5	
	CD (0.05)			CD (0.05)		
	Spacing	NS		Spacing	NS	
	Pruning	NS		Pruning	0.6	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

It was also observed that the differences in the mean fruiting density in all the spacings were found non-significant during the winter season (Table 32). Irrespective of spacings the pruning effect was found significant. The mean fruiting density 15.5 fruits/m³ were found in pruned trees and in un-pruned trees it was 8.9 fruits/m³. The interaction between spacing and pruning was statistically found non significant.

4.4.7 Yield efficiency

The data related to yield efficiency was given in Table 33 during the rainy and winter seasons. The data revealed that yield efficiency was significantly different among the various treatments. Yield efficiency increased with increasing the spacing and pruning levels during the rainy season. The yield efficiency was significantly affected by the plant spacings. The yield efficiency was found significantly higher (151.2%) in wider spacing (6×6 m) trees as compared to all other spacings whereas, it was recorded significantly lesser (124.6%) in closer spacing (5×2 m) trees. The yield efficiency was also significantly affected by the pruning treatments. The mean yield efficiency 145.7 per cent was recorded in pruned trees and 131.3 per cent registered in un-pruned trees. The interaction effect between spacing and pruning for yield efficiency was found non significant.

It was observed that yield efficiency significantly increased with increasing the spacing and pruning level during the winter season (Table 33). Highest mean yield efficiency (139.2 %) was recorded from trees spaced at 6×6 m which was at par with 6×5 m spacing and followed by 5×5 m, 6×4 m and minimum (110.6 %) was recorded in trees spaced at 5×3 m

and 5×2 m. Pruning effect also found significant. The yield efficiency 162.7 per cent was recorded in pruned trees and 85.9 per cent in un-pruned trees. The interaction between the spacing and pruning was statistically found non significant.

Table 33: Effect of spacing and pruning on the yield efficiency (%) of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	119.1	137.1	128.5	75.1	146.6	110.8
6 x 3	130.1	146.3	138.2	83.1	157.5	120.3
6 x 4	135.9	145.4	140.7	90.1	172.9	131.5
6 x 5	137.0	149.9	143.5	95.3	174.8	135.0
5 x 2	116.2	133.0	124.6	70.3	150.8	110.6
5 x 3	120.1	139.8	130.4	75.7	145.4	110.6
5 x 4	137.4	147.5	142.5	87.9	166.9	127.4
5 x 5	139.8	153.7	146.7	93.1	173.7	133.4
6 x 6	144.1	158.4	151.2	102.4	176.0	139.2
Mean	131.3	145.7		85.9	162.7	
	CD (0.05)			CD (0.05)		
	Spacing	12.4		Spacing	10.2	
	Pruning	5.9		Pruning	4.8	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

4.5 Fruit quality parameter

4.5.1 Fruit firmness

The perusal of data in table 34 clearly indicates that fruit firmness was significantly different among the spacings and pruning treatments during the rainy season. The fruit firmness was significantly affected by the plant spacings. Among the treatments maximum (4.62 lb/inch²) mean fruit firmness was recorded in fruits harvested from the trees spaced at 6×6 m which was at par with trees spaced at 6×5 m and minimum (3.77 lb/inch²) was noticed in fruits harvested from trees spaced at 5×2 m. Pruning effect also found significant. The mean fruit firmness 4.53 lb/inch² was found in fruits harvested from pruned trees and 3.87 lb/inch² was recorded in fruits harvested from un-pruned trees. The fruit firmness was also significantly affected by the different parts of tree canopy. The upper part of the tree canopy exhibited significantly higher (4.40 lb/inch²) mean fruit firmness than the middle and lower canopy part. The interaction between spacing and pruning was found significant. Highest mean fruit firmness (4.99 lb/inch²) was found in fruits harvested from the wider spacing (6×6 m) of pruned trees and lowest fruit firmness (3.56 lb/inch²) was noticed in fruits harvested from the un-pruned trees.

Table 34: Effect of spacing, pruning and the part of tree canopy on fruit firmness (lb/inch²) of guava cv. Hisar Safeda during the rainy season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	3.87	3.64	3.20	4.32	4.19	4.01		
6 x 3	4.13	3.72	3.35	4.62	4.42	4.20		
6 x 4	4.24	4.06	3.67	4.82	4.65	4.54		
6 x 5	4.28	4.22	3.96	5.02	4.90	4.72		
5 x 2	3.87	3.63	3.17	4.21	4.00	3.71		
5 x 3	3.79	3.60	3.43	4.53	4.33	4.13		
5 x 4	4.07	3.83	3.61	4.70	4.55	4.48		
5 x 5	4.26	4.15	3.87	4.93	4.75	4.65		
6 x 6	4.32	4.30	4.14	5.20	5.00	4.81		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	3.57	4.17	3.87	6 x 2	4.10	3.92	3.61	3.87
6 x 3	3.73	4.41	4.07	6 x 3	4.37	4.07	3.78	4.07
6 x 4	3.99	4.67	4.33	6 x 4	4.53	4.36	4.11	4.33
6 x 5	4.15	4.88	4.52	6 x 5	4.65	4.56	4.34	4.52
5 x 2	3.56	3.97	3.77	5 x 2	4.04	3.82	3.44	3.77
5 x 3	3.61	4.33	3.97	5 x 3	4.16	3.97	3.78	3.97
5 x 4	3.84	4.58	4.21	5 x 4	4.39	4.20	4.05	4.21
5 x 5	4.10	4.78	4.44	5 x 5	4.60	4.46	4.27	4.44
6 x 6	4.25	4.99	4.62	6 x 6	4.76	4.64	4.47	4.62
Mean	3.87	4.53		Mean	4.40	4.22	3.98	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing			0.06
Non pruned	4.09	3.91	3.60	3.87	Pruning			0.03
Pruned	4.71	4.53	4.36	4.53	Canopy			0.03
Mean	4.40	4.22	3.98		Spacing x Pruning			0.08
					Spacing x Canopy			0.10
					Pruning x Canopy			0.05
					Spacing x Pruning x Canopy			0.14

The interaction effect between spacing and canopy was also found significant. The fruit firmness (4.76 lb/inch²) was recorded significantly higher in fruits harvested from upper canopy part of wider spacing (6×6 m) trees as compared all other spacings of different canopy part, whereas, it was observed significantly lower (3.44 lb/inch²) in fruits harvested from lower canopy part of closer spacing (5×2 m) trees. The interaction between pruning and canopy was also found significant. Maximum fruit firmness (4.71 lb/inch²) was recorded in fruits harvested from upper canopy part of pruned trees whereas, minimum (3.60 lb/inch²)

was observed in fruits harvested from lower canopy part of un-pruned trees. The interaction among the spacing, pruning and canopy was also statistically found significant. Highest fruit firmness (5.20 lb/inch²) was observed in fruits harvested from upper canopy part of wider spacing (6×6 m) of pruned trees as compared all other spacings of different canopy part of pruned and un-pruned trees. Lowest fruit firmness (3.17 lb/inch²) was noticed in fruits harvested from lower canopy part of closer spacing (5×2 m) of un-pruned trees.

Table 35: Effect of spacing, pruning and the part of tree canopy on fruit firmness (lb/inch²) of guava cv. Hisar Safeda during the winter season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	6.60	6.48	6.32	7.35	7.26	7.08		
6 x 3	6.86	6.72	6.59	7.55	7.36	7.21		
6 x 4	7.11	6.93	6.66	7.71	7.58	7.43		
6 x 5	7.24	7.09	6.94	7.88	7.74	7.61		
5 x 2	6.47	6.31	6.21	7.30	7.18	7.00		
5 x 3	6.74	6.57	6.49	7.60	7.41	7.2		
5 x 4	6.96	6.84	6.67	7.65	7.53	7.38		
5 x 5	7.21	7.06	6.87	7.82	7.66	7.50		
6 x 6	7.28	7.18	7.00	7.93	7.82	7.7		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	6.47	7.23	6.85	6 x 2	6.98	6.87	6.70	6.85
6 x 3	6.72	7.37	7.05	6 x 3	7.20	7.04	6.90	7.05
6 x 4	6.90	7.57	7.24	6 x 4	7.41	7.25	7.05	7.24
6 x 5	7.09	7.74	7.42	6 x 5	7.56	7.41	7.27	7.42
5 x 2	6.33	7.16	6.75	5 x 2	6.89	6.75	6.61	6.75
5 x 3	6.60	7.40	7.00	5 x 3	7.17	6.99	6.84	7.00
5 x 4	6.82	7.52	7.17	5 x 4	7.31	7.18	7.03	7.17
5 x 5	7.05	7.66	7.36	5 x 5	7.52	7.36	7.19	7.36
6 x 6	7.15	7.82	7.49	6 x 6	7.61	7.50	7.35	7.49
Mean	6.79	7.50		Mean	7.29	7.15	6.99	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning Canopy Spacing x Pruning Spacing x Canopy Pruning x Canopy Spacing x Pruning x Canopy			
Non pruned	6.94	6.80	6.64	6.79				0.04
Pruned	7.65	7.50	7.35	7.50				0.02
Mean	7.29	7.15	6.99					0.02
								0.06
								NS
								NS
								NS

The perusal of data in table 35 clearly indicates that there was significant variation exists among the various treatments. The data shows that the fruit firmness was significantly affected by the plant spacings. The mean fruit firmness (7.49 lb/inch²) was found significantly

maximum in fruits harvested from wider spacing (6×6 m) as compared all other plant spacings whereas, minimum mean fruit firmness (6.75 lb/inch²) was observed in fruits harvested from closer spacing (5×2 m). The pruning effect also found significant. The mean fruit firmness 7.50 lb/inch² was found in fruits harvested from pruned trees and 6.79 lb/inch² was observed in fruits harvested from un-pruned trees. The fruit firmness was also significantly affected by the different parts of tree canopy. The upper part of the tree canopy exhibited significantly higher (7.29 lb/inch²) mean fruit firmness than the middle and lower canopy part. The interaction between spacing and pruning was statistically found significant. Highest (7.82 lb/inch²) mean fruit firmness was found in fruits harvested from the wider spacing (6×6 m) of pruned trees and lowest fruit firmness (6.33 lb/inch²) was noticed in fruits harvested from the un-pruned trees. The interactive effect of between spacing, canopy and pruning, canopy on firmness of fruits was non significant. The interaction among the spacing, pruning and canopy also found non significant.

4.5.2 Total soluble solids

The observation on total soluble solids revealed that significant variation exists among the treatments during the rainy season (Table 36). The fruit TSS was significantly affected by the plant spacings. Highest TSS (11.29%) was found in fruits harvested from trees spaced at 6×6 and lowest (9.91 %) was observed in fruits harvested from trees spaced at 5×2 m. The fruit TSS was also significantly affected by the pruning treatments. The mean TSS 11.16 per cent was recorded in fruits harvested from pruned trees and 10.06 per cent TSS was found in fruits harvested from un-pruned trees. The fruit TSS was significantly affected by the different parts of tree canopy. Fruit TSS was recorded significantly higher (10.75%) in fruits harvested from upper part of canopy as compared to other parts of tree canopy whereas, lowest (10.46 %) TSS was found in fruits harvested from lower part of tree canopy. The interaction between spacing and pruning treatment was found significant. Maximum fruit TSS (11.76 %) was recorded in fruits harvested from wider spacing (6×6) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas, minimum (9.76 %) was observed in fruits harvested from closer spacing (5×2 m) of un-pruned trees. The interactive effect between spacing, canopy and pruning, canopy as well as among the spacing, pruning and canopy was statistically found non significant.

Table 36: Effect of spacing, pruning and the part of tree canopy on total soluble solids (%) of guava cv. Hisar Safeda during the rainy season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	9.75	9.62	9.46	10.80	10.59	10.41		
6 x 3	9.92	9.81	9.67	11.16	11.04	10.92		
6 x 4	10.40	10.24	9.96	11.51	11.40	11.27		
6 x 5	10.82	10.59	10.45	11.73	11.61	11.49		
5 x 2	9.54	9.38	9.26	10.56	10.44	10.26		
5 x 3	9.87	9.78	9.63	11.00	10.81	10.67		
5 x 4	10.02	9.94	9.82	11.39	11.26	11.13		
5 x 5	10.57	10.43	10.26	11.62	11.52	11.39		
6 x 6	10.97	10.81	10.67	11.89	11.78	11.60		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	9.61	10.60	10.11	6 x 2	10.28	10.11	9.94	10.11
6 x 3	9.80	11.04	10.42	6 x 3	10.54	10.43	10.30	10.42
6 x 4	10.20	11.39	10.80	6 x 4	10.95	10.82	10.62	10.80
6 x 5	10.62	11.61	11.12	6 x 5	11.28	11.10	10.97	11.12
5 x 2	9.39	10.42	9.91	5 x 2	10.05	9.91	9.76	9.91
5 x 3	9.76	10.83	10.30	5 x 3	10.44	10.30	10.15	10.30
5 x 4	9.93	11.26	10.60	5 x 4	10.71	10.60	10.48	10.60
5 x 5	10.42	11.51	10.97	5 x 5	11.10	10.97	10.83	10.97
6 x 6	10.82	11.76	11.29	6 x 6	11.43	11.30	11.14	11.29
Mean	10.06	11.16		Mean	10.75	10.62	10.46	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning Canopy			0.04 0.02 0.02
Non pruned	10.21	10.07	9.91	10.06	Spacing x Pruning			0.5
Pruned	11.30	11.16	11.02	11.16	Spacing x Canopy			NS
Mean	10.75	10.62	10.46		Pruning x Canopy			NS
					Spacing x Pruning x Canopy			NS

The perusal of data in table 37 clearly indicates that fruit TSS was significantly increased with increasing the plant spacings, pruning levels and decreasing with the depth of tree canopy during the winter season. Maximum (12.39%) TSS was found in fruits harvested from trees spaced at 6×6 m and minimum (11.17%) was observed in fruits harvested from trees spaced at 5×2 m. The fruit TSS was also significantly affected by the pruning treatments. The mean fruit TSS 12.10 per cent was found in fruits harvested from pruned trees and 11.40 per cent TSS was noticed in fruits harvested from the un-pruned trees. Irrespective of spacing and pruning fruit TSS was also significantly affected by the different parts of tree canopy.

Table 37: Effect of spacing, pruning and the part of tree canopy on total soluble solids (%) of guava cv. Hisar Safeda during the winter season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	11.04	11.87	10.76	11.78	11.67	11.53		
6 x 3	11.33	11.23	11.04	12.01	11.83	11.44		
6 x 4	11.68	11.58	11.44	12.48	12.34	12.13		
6 x 5	11.89	11.77	11.55	12.53	12.41	12.32		
5 x 2	10.96	10.76	10.62	11.69	11.57	11.42		
5 x 3	11.11	11.96	10.84	12.17	12.05	11.79		
5 x 4	11.62	11.43	11.39	12.31	12.19	12.01		
5 x 5	11.79	11.66	11.55	12.49	12.37	12.16		
6 x 6	12.35	12.30	12.09	12.69	12.54	12.37		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	10.89	11.66	11.28	6 x 2	11.41	11.27	11.15	11.28
6 x 3	11.20	11.87	11.54	6 x 3	11.67	11.53	11.41	11.54
6 x 4	11.57	12.32	11.95	6 x 4	12.08	11.96	11.79	11.95
6 x 5	11.74	12.42	12.08	6 x 5	12.21	12.09	11.94	12.08
5 x 2	10.78	11.56	11.17	5 x 2	11.33	11.16	11.02	11.17
5 x 3	10.97	12.00	11.49	5 x 3	11.64	11.51	11.32	11.49
5 x 4	11.48	12.17	11.83	5 x 4	11.96	11.82	11.70	11.83
5 x 5	11.67	12.34	12.01	5 x 5	12.14	12.02	11.86	12.01
6 x 6	12.25	12.53	12.39	6 x 6	12.52	12.42	12.23	12.39
Mean	11.40	12.10		Mean	11.89	11.75	11.60	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	11.53	11.40	11.26	11.40	Spacing			0.03
Pruned	12.24	12.11	11.94	12.10	Pruning			0.02
Mean	11.89	11.75	11.60		Canopy			0.02
					Spacing x Pruning			0.5
					Spacing x Canopy			NS
					Pruning x Canopy			NS
					Spacing x Pruning x Canopy			0.08

Fruit TSS was recorded significantly higher (11.89 %) in fruits harvested from upper part of canopy as compared to middle and lower part of tree canopy. Similarly, fruit TSS was recorded significantly higher (11.75 %) in fruits harvested from middle part of tree canopy than the TSS (11.60 %) recorded in fruits harvested from lower part of tree canopy. The interaction between spacing and pruning treatment was found significant. Maximum fruit TSS (12.53 %) was recorded in fruits harvested from wider spacing (6×6) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas minimum (10.78 %) was observed in fruits harvested from closer spacing (5×2 m) of un-pruned trees. The interaction between spacing and canopy as well as pruning and canopy was found non significant, whereas,

interaction among the spacing, pruning and canopy was statistically found significant. Maximum TSS (12.69 %) was observed in fruits harvested from upper canopy part of wider spacing (6×6 m) of pruned trees as compared all other spacings of different canopy part of pruned and un-pruned trees, whereas, minimum TSS (10.62%) was noticed in fruits harvested from lower canopy part of closer spacing (5×2 m) of un-pruned trees.

4.5.3 Total sugars

The perusal of data (Table 38) clearly indicate that total sugars content was significantly increased with increasing the spacing, pruning treatments and decreasing with the depth of tree canopy .

Table 38: Effect of spacing, pruning and the part of tree canopy on total sugars (%) of guava cv. Hisar Safeda during the rainy season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	4.10	3.85	3.72	5.46	5.37	5.16		
6 x 3	4.30	4.19	3.99	5.74	5.63	5.49		
6 x 4	4.38	4.32	4.17	6.05	5.91	5.82		
6 x 5	4.53	4.40	4.27	6.58	6.44	6.27		
5 x 2	4.07	3.82	3.68	5.16	5.05	4.88		
5 x 3	4.16	4.01	3.85	5.49	5.40	5.25		
5 x 4	4.37	4.29	4.13	5.98	5.88	5.72		
5 x 5	4.50	4.37	4.24	6.38	6.18	6.04		
6 x 6	4.61	4.50	4.41	6.76	6.64	6.49		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	3.89	5.33	4.61	6 x 2	4.78	4.61	4.44	4.61
6 x 3	4.16	5.62	4.89	6 x 3	5.02	4.91	4.74	4.89
6 x 4	4.29	5.93	5.11	6 x 4	5.22	5.12	5.00	5.11
6 x 5	4.40	6.43	5.42	6 x 5	5.55	5.42	5.27	5.42
5 x 2	3.86	5.03	4.45	5 x 2	4.62	4.44	4.28	4.45
5 x 3	4.01	5.38	4.69	5 x 3	4.83	4.71	4.55	4.69
5 x 4	4.26	5.86	5.06	5 x 4	5.18	5.08	4.92	5.06
5 x 5	4.37	6.20	5.29	5 x 5	5.44	5.28	5.14	5.29
6 x 6	4.51	6.63	5.57	6 x 6	5.69	5.57	5.45	5.57
Mean	4.20	5.82		Mean	5.15	5.01	4.87	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
Non pruned	4.34	4.20	4.05	4.20	Spacing			0.03
Pruned	5.96	5.83	5.68	5.82	Pruning			0.01
Mean	5.15	5.01	4.87		Canopy			0.02
					Spacing x Pruning			0.04
					Spacing x Canopy			NS
					Pruning x Canopy			NS
					Spacing x Pruning x Canopy			0.07

Maximum total sugars content (5.57%) was found in fruits harvested from trees spaced at 6×6 m and minimum (4.45 %) was recorded in fruits harvested from trees spaced at 5×2 m. Pruning effect also found significant. The mean fruit total sugars 5.82 per cent was observed in fruits harvested from pruned trees and 4.20 per cent was recorded in fruits harvested from un-pruned trees. The total sugars also significantly affected by the different parts of tree canopy. Highest mean total sugar content (5.15 %) was observed in fruits harvested from upper part of tree canopy, which was significantly higher than all other parts of tree canopy. Lowest total sugars (4.87 %) were found in fruits harvested from lower part of tree canopy. The interaction effect between spacing and pruning for total sugars content was also found significant. Maximum total sugars (6.63 %) was recorded in fruits harvested from wider spacing (6×6) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas minimum (3.86 %) was observed in fruits harvested from closer spacing (5×2 m) of un-pruned trees. The interactive effect between spacing and canopy as well as pruning and canopy was found non significant, whereas interaction among the spacing, pruning and canopy was found significant. Highest total sugars (6.76 %) was recorded in fruits harvested from upper canopy part of wider spacing (6×6 m) of pruned trees as compared to all other spacings of different canopy part of pruned and un-pruned trees, whereas, lowest total sugars (3.68 %) was noticed in fruits harvested from lower canopy part of closer spacing (5×2 m) of un-pruned trees.

The data shown in table 39 clearly indicates that significant difference exists among the treatments. Maximum mean total sugar content (6.63 %) was recorded in fruit harvested from trees at 6×6 m spacing and minimum (5.05%) was observed in fruits harvested from trees spaced at 5×2 m. The total sugar also significantly affected by the pruning treatments. The total sugars 6.99 per cent was observed in fruits harvested from pruned trees and 4.65 per cent was recorded in fruits harvested from un-pruned trees. The total sugars were also significantly affected by the different parts of tree canopy. Maximum total sugar content (5.93 %) was observed in fruits harvested from upper part of tree canopy, which was significantly higher than all other parts of tree canopy. Lowest total sugars (5.71 %) were found in fruits harvested from lower part of tree canopy. The interaction effect between spacing and pruning for total sugars content was also found significant. Maximum total sugars (7.87 %) was recorded in fruits harvested from wider spacing (6×6) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas, minimum (4.23 %) was observed in fruits harvested from closer spacing (5×2 m) of un-pruned trees. The interaction effect between spacing and canopy for total sugars content was also found significant. Maximum (6.74 %) total sugars was observed in fruits harvested from upper part of wider spacing (6×6 m) trees as compared to all other spacings of different canopy part. The interaction between pruning and canopy was found non significant. The interaction among the spacing, pruning and

canopy was statistically found significant. Highest total sugars (7.97 %) was recorded in fruits harvested from upper canopy part of wider spacing (6×6 m) of pruned trees as compared all other spacings of different canopy part of pruned and un-pruned trees, whereas, lowest total sugars (4.09 %) was noticed in fruits harvested from lower canopy part of closer spacing (5×2 m) of un-pruned trees.

Table 39: Effect of spacing, pruning and the part of tree canopy on total sugars (%) of guava cv. Hisar Safeda during the winter season

Spacing x Pruning x Canopy (S x P x C)								
Pruning → Canopy → Spacing(m) ↓	Non pruned (Np)			Pruned (P)				
	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	4.44	4.35	4.20	6.38	6.18	6.03		
6 x 3	4.62	4.49	4.33	6.83	6.74	6.62		
6 x 4	4.73	4.63	4.50	7.48	7.37	7.25		
6 x 5	5.34	5.24	5.12	7.76	7.70	7.65		
5 x 2	4.36	4.23	4.09	6.01	5.86	5.75		
5 x 3	4.46	4.38	4.25	6.53	6.43	6.33		
5 x 4	4.60	4.50	4.40	7.29	7.17	7.05		
5 x 5	4.75	4.71	4.67	7.66	7.58	7.47		
6 x 6	5.50	5.40	5.28	7.97	7.88	7.56		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	4.33	6.20	5.27	6 x 2	5.41	5.27	5.12	5.27
6 x 3	4.48	6.73	5.61	6 x 3	5.73	5.61	5.48	5.61
6 x 4	4.62	7.37	6.00	6 x 4	6.11	6.00	5.88	5.600
6 x 5	5.23	7.70	6.47	6 x 5	6.55	6.47	6.39	6.47
5 x 2	4.23	5.87	5.05	5 x 2	5.18	5.05	4.92	5.05
5 x 3	4.36	6.43	5.40	5 x 3	5.50	5.40	5.29	5.40
5 x 4	4.50	7.17	5.84	5 x 4	5.95	5.84	5.72	5.84
5 x 5	4.71	7.57	6.14	5 x 5	6.20	6.15	6.07	6.14
6 x 6	5.39	7.87	6.63	6 x 6	6.74	6.64	6.52	6.63
Mean	4.65	6.99		Mean	5.93	5.82	5.71	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean				
					Spacing			0.02
Non pruned	4.76	4.66	4.54	4.65	Pruning			0.01
Pruned	7.10	6.99	6.88	6.99	Canopy			0.01
Mean	5.93	5.82	5.71		Spacing x Pruning			0.03
					Spacing x Canopy			0.04
					Pruning x Canopy			NS
					Spacing x Pruning x Canopy			0.05

4.5.4 Ascorbic acid

The perusal of data in table 40 clearly indicates that ascorbic acid content of fruits was significantly increased with increasing the plant spacings, pruning levels and decreased with increasing the depth of tree canopy during the winter season.

Table 40: Effect of spacing, pruning and the part of tree canopy on ascorbic acid (mg/100g of pulp) of guava cv. Hisar Safeda during the rainy season

Spacing x Pruning x Canopy (S x P x C)								
Pruning → Canopy → Spacing(m) ↓	Non pruned (Np)			Pruned (P)				
	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	148.5	146.9	145.3	157.9	156.8	155.1		
6 x 3	151.2	149.7	147.6	161.8	160.8	158.0		
6 x 4	153.7	152.5	150.7	165.3	163.8	162.6		
6 x 5	158.4	156.5	154.9	169.3	167.5	165.9		
5 x 2	146.4	144.9	143.4	156.4	154.7	153.7		
5 x 3	149.8	148.0	156.5	159.2	157.8	156.7		
5 x 4	152.7	151.2	149.3	163.7	162.4	160.7		
5 x 5	156.0	154.6	153.1	167.9	166.2	164.6		
6 x 6	159.9	158.5	156.6	171.4	169.9	167.5		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	146.9	156.6	151.7	6 x 2	153.2	151.9	150.2	151.8
6 x 3	149.5	160.2	154.9	6 x 3	156.5	155.3	152.8	154.9
6 x 4	152.3	163.9	158.1	6 x 4	159.5	158.2	156.6	158.1
6 x 5	156.6	167.6	162.1	6 x 5	163.8	162.0	160.4	162.1
5 x 2	144.9	154.9	149.9	5 x 2	151.4	149.8	148.6	149.9
5 x 3	148.1	157.9	153.0	5 x 3	154.5	152.9	151.6	153.0
5 x 4	151.0	162.2	156.6	5 x 4	158.2	156.8	155.0	156.6
5 x 5	154.5	166.2	160.4	5 x 5	161.9	160.4	158.8	160.4
6 x 6	158.3	169.6	164.0	6 x 6	165.6	164.2	162.1	164.0
Mean	151.4	162.1		Mean	158.3	156.8	155.1	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning Canopy Spacing x Pruning Spacing x Canopy Pruning x Canopy Spacing x Pruning x Canopy			
Non pruned	152.9	151.4	149.7	151.4				0.03
Pruned	163.7	162.2	160.5	162.1				0.01
Mean	158.3	156.8	155.1					0.02
								0.04
								NS
								NS
								0.07

Maximum ascorbic acid (164.0 mg/100g) was found in fruits harvested from trees spaced at 6×6 m and minimum (149.9 mg/100g) was noticed in fruits harvested from trees spaced at 5×2 m. The ascorbic acid content was also significantly affected by the pruning treatments. The mean ascorbic acid 162.1 mg/100g was found in fruits harvested from pruned trees and 151.4 mg/100g mean ascorbic acid was observed in fruits harvested from the un-pruned trees. Irrespective of spacing and pruning ascorbic acid content was also significantly affected by the different parts of tree canopy. The ascorbic acid content was recorded significantly higher (158.3 mg/100g) in fruits harvested from upper part of tree canopy as compared middle and

lower part of tree canopy. The interaction between spacing and pruning treatments was also statistically found significant. Maximum fruit ascorbic acid (169.6 mg/100g) was found in fruits harvested from wider spacing (6×6) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas, minimum ascorbic acid content (144.9 mg/100g) was observed in fruits harvested from closer spacing (5×2 m) of un-pruned trees. The interaction between spacing and canopy as well as pruning and canopy was found non significant, whereas interaction among the spacing, pruning and canopy was statistically found significant. Maximum ascorbic acid content (171.4 mg/100g) was observed in fruits harvested from upper canopy part of wider spacing (6×6 m) of pruned trees as compared all other spacings of different canopy part of pruned and un-pruned trees, whereas, minimum ascorbic acid content (143.4 mg/100g) was found in fruits harvested from lower canopy part of closer spacing (5×2 m) of un-pruned trees.

The ascorbic acid content was also significantly varied among the various treatments during the winter season (Table 41). Maximum ascorbic acid content (182.0 mg/100g) was found in fruits harvested from trees spaced at 6×6 m and minimum (166.9 mg/100g) was recorded in fruits harvested from trees spaced at 5×2 m. Pruning effect also found significant. The mean ascorbic acid content 179.7 mg/100g was observed in fruits harvested from pruned trees and 171.0 mg/100g was recorded in fruits harvested from un-pruned trees. The ascorbic acid content was also significantly affected by the different parts of tree canopy. Highest mean ascorbic acid content (176.7 mg/100g) was observed in fruits harvested from upper part of tree canopy, which was significantly higher than all other parts of tree canopy. Lowest ascorbic acid content (174.1 mg/100g) was found in fruits harvested from lower part of tree canopy. The interaction effect between spacing and pruning for ascorbic acid content was also found significant. Highest ascorbic acid content (187.3 mg/100g) was recorded in fruits harvested from wider spacing (6×6) of pruned trees as compared to all other spacings of pruned and un-pruned trees, whereas, lesser (162.2 mg/100g) was noticed in fruits harvested from closer spacing (5×2 m) of un-pruned trees. The interactive effect between spacing, canopy and pruning, canopy was found non significant, whereas, interaction among the spacing, pruning and canopy was statistically found significant. Maximum ascorbic acid content (188.7 mg/100g) was recorded in fruits harvested from upper canopy part of wider spacing (6×6 m) of pruned trees as compared to all other spacings of different canopy part of pruned and un-pruned trees, whereas, lowest ascorbic acid content (160.8 mg/100g) was noticed in fruits harvested from lower canopy part of closer spacing (5×2 m) of un-pruned trees.

Table 41: Effect of spacing, pruning and the part of tree canopy on ascorbic acid (mg/100g of pulp) of guava cv. Hisar Safeda during the winter season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	166.6	165.2	163.5	176.1	174.4	173.1		
6 x 3	172.1	171.0	169.4	179.4	178.1	176.4		
6 x 4	174.7	173.2	171.9	183.0	181.7	180.9		
6 x 5	176.7	175.4	174.7	186.3	184.9	183.9		
5 x 2	163.8	162.0	160.8	172.5	171.6	170.7		
5 x 3	170.0	168.1	166.8	177.5	176.6	175.0		
5 x 4	173.8	172.7	171.1	180.6	179.2	178.1		
5 x 5	175.5	174.6	173.2	184.7	183.5	182.3		
6 x 6	178.0	176.2	175.5	188.7	187.1	186.2		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	165.1	174.5	169.8	6 x 2	171.4	169.8	168.3	169.8
6 x 3	170.8	177.9	174.4	6 x 3	175.8	174.5	172.9	174.4
6 x 4	173.2	181.8	177.5	6 x 4	178.8	177.4	176.4	177.5
6 x 5	175.6	185.0	180.3	6 x 5	181.5	180.2	179.3	180.3
5 x 2	162.2	171.6	166.9	5 x 2	168.2	166.8	165.8	166.9
5 x 3	168.4	176.3	172.4	5 x 3	173.8	172.3	170.9	172.4
5 x 4	172.5	179.3	175.9	5 x 4	177.2	176.0	174.6	175.9
5 x 5	174.4	183.5	179.0	5 x 5	180.1	179.1	177.8	179.0
6 x 6	176.6	187.3	182.0	6 x 6	183.3	181.7	180.8	182.0
Mean	171.0	179.7		Mean	176.7	175.3	174.1	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning Canopy Spacing x Pruning Spacing x Canopy Pruning x Canopy Spacing x Pruning x Canopy			
Non pruned	172.4	170.9	169.8	171.0				0.03
Pruned	181.0	179.7	178.5	179.7				0.01
Mean	176.7	175.3	174.1					0.02
								0.04
								NS
								NS
								0.07

4.5.5 Titratable acidity

The data presented in table 42 shows that there was significant variation exists among the various treatments. Maximum mean acid content (0.65 %) was recorded in fruits harvested from the closer spacing (5×2 m) as compared to all other spacing, whereas, minimum acid content (0.52 %) was found in fruits harvested from wider spacing (6×6 m).

Table 42: Effect of spacing, pruning and the part of tree canopy on titratable acidity (%) of guava cv. Hisar Safeda during the rainy season

Spacing x Pruning x Canopy (S x P x C)								
Pruning →	Non pruned (Np)			Pruned (P)				
Canopy → Spacing(m) ↓	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	0.64	0.66	0.68	0.57	0.60	0.61		
6 x 3	0.64	0.65	0.67	0.53	0.55	0.58		
6 x 4	0.60	0.64	0.66	0.49	0.51	0.53		
6 x 5	0.57	0.60	0.61	0.47	0.49	0.51		
5 x 2	0.67	0.69	0.70	0.58	0.60	0.62		
5 x 3	0.64	0.66	0.68	0.55	0.57	0.59		
5 x 4	0.63	0.64	0.67	0.51	0.53	0.55		
5 x 5	0.58	0.60	0.62	0.47	0.50	0.52		
6 x 6	0.55	0.57	0.58	0.46	0.48	0.49		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	0.66	0.59	0.63	6 x 2	0.60	0.63	0.65	0.63
6 x 3	0.65	0.55	0.60	6 x 3	0.58	0.60	0.63	0.60
6 x 4	0.63	0.51	0.57	6 x 4	0.55	0.58	0.59	0.57
6 x 5	0.59	0.49	0.54	6 x 5	0.52	0.54	0.56	0.54
5 x 2	0.69	0.60	0.65	5 x 2	0.63	0.65	0.67	0.65
5 x 3	0.66	0.57	0.62	5 x 3	0.60	0.62	0.64	0.62
5 x 4	0.64	0.53	0.59	5 x 4	0.57	0.59	0.61	0.59
5 x 5	0.60	0.50	0.55	5 x 5	0.53	0.55	0.57	0.55
6 x 6	0.56	0.48	0.52	6 x 6	0.50	0.52	0.54	0.52
Mean	0.63	0.54		Mean	0.57	0.59	0.61	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning Canopy Spacing x Pruning Spacing x Canopy Pruning x Canopy Spacing x Pruning x Canopy			0.00 0.00 0.00 0.01 NS NS NS
Non pruned	0.61	0.63	0.65	0.63				
Pruned	0.52	0.54	0.56	0.54				
Mean	0.57	0.59	0.61					

The acid content of fruits was also significantly affected by the pruning treatments. The mean acid content 0.63 per cent was recorded in fruits harvested from un-pruned trees and 0.54 per cent was found in fruits harvested from pruned trees. The acid content of fruits was also significantly affected by the different parts of tree canopy. Maximum mean acid content (0.61%) was found in fruits harvested from the lower part of tree canopy as compared to middle and upper part of tree canopy whereas, minimum (0.57%) was recorded in fruits harvested from the upper part of tree canopy. The interaction effect between spacing, pruning

and pruning, canopy and interaction among the spacing, pruning and canopy for acid content in fruit was statistically found non significant.

The perusal of data (Table 43) shows that acid content of fruits significantly increased with increasing the plant densities, pruning levels and depth of tree canopy during the winter season.

Table 43: Effect of spacing, pruning and the part of tree canopy on titratable acidity (%) of guava cv. Hisar Safeda during the winter season

Spacing x Pruning x Canopy (S x P x C)								
Pruning → Canopy → Spacing(m) ↓	Non pruned (Np)			Pruned (P)				
	Upper	Middle	Lower	Upper	Middle	Lower		
6 x 2	0.59	0.62	0.64	0.50	0.52	0.54		
6 x 3	0.58	0.59	0.61	0.47	0.49	0.51		
6 x 4	0.53	0.55	0.58	0.43	0.45	0.47		
6 x 5	0.50	0.52	0.54	0.40	0.42	0.44		
5 x 2	0.60	0.63	0.65	0.53	0.54	0.56		
5 x 3	0.59	0.61	0.62	0.50	0.52	0.54		
5 x 4	0.56	0.58	0.60	0.46	0.48	0.50		
5 x 5	0.52	0.54	0.56	0.40	0.43	0.45		
6 x 6	0.48	0.50	0.51	0.37	0.39	0.41		
Spacing x Pruning (S x P)				Spacing x Canopy (S x C)				
Pruning → Spacing(m) ↓	Non Pruned	Pruned	Mean (S)	Canopy → Spacing(m) ↓	Upper	Middle	Lower	Mean (S)
6 x 2	0.62	0.52	0.57	6 x 2	0.55	0.57	0.59	0.57
6 x 3	0.59	0.49	0.54	6 x 3	0.53	0.54	0.56	0.54
6 x 4	0.55	0.45	0.50	6 x 4	0.48	0.50	0.52	0.50
6 x 5	0.52	0.42	0.47	6 x 5	0.45	0.47	0.49	0.47
5 x 2	0.63	0.54	0.58	5 x 2	0.56	0.59	0.61	0.59
5 x 3	0.60	0.52	0.56	5 x 3	0.54	0.56	0.58	0.56
5 x 4	0.58	0.48	0.53	5 x 4	0.51	0.53	0.55	0.53
5 x 5	0.54	0.43	0.49	5 x 5	0.47	0.49	0.50	0.49
6 x 6	0.50	0.39	0.44	6 x 6	0.43	0.45	0.46	0.44
Mean	0.57	0.47		Mean	0.50	0.52	0.54	
Pruning x Canopy (P x C)				CD (0.05)				
Canopy → Pruning ↓	Upper	Middle	Lower	Mean	Spacing Pruning Canopy			0.00 0.00 0.00
Non pruned	0.55	0.57	0.59	0.57	Spacing x Pruning			0.01
Pruned	0.45	0.47	0.49	0.47	Spacing x Canopy			NS
Mean	0.50	0.52	0.54		Pruning x Canopy			NS
					Spacing x Pruning x Canopy			NS

The acid content of fruits was significantly affected by the plant densities. Maximum mean acid content (0.58 %) was recorded in fruits harvested from trees spaced 5×2 m spacing and lowest acid content (0.44 %) was found in fruits harvested from trees spaced at 6×6 m. The acid content of fruits was also significantly affected by the pruning treatments. The mean acid content 0.57 per cent was recorded in fruits harvested from un-pruned trees and 0.47 per cent was noticed in fruits harvested from pruned trees. The acid content of fruits was also significantly affected by the different parts of tree canopy. The mean acid content was found significantly higher (0.54 %) in fruits harvested from the lower part of tree canopy as compared to middle and upper part of tree canopy whereas, minimum (0.50%) was recorded in fruits harvested from the upper part of tree canopy. The interaction effect between spacing, pruning and pruning, canopy and interaction among the spacing, pruning and canopy for acid content in fruit was statistically found non significant.

4.6 Estimation of Leaf NPK

4.6.1 Nitrogen

Data on leaf N content during the rainy and winter season is presented in table 44. Leaf N content was significantly affected by plant spacings and pruning levels during the rainy season.

Table 44: Effect of spacing and pruning on nitrogen content (%) in leaves of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	1.51	1.58	1.54	1.43	1.46	1.45
6 x 3	1.54	1.62	1.58	1.45	1.50	1.48
6 x 4	1.58	1.67	1.62	1.48	1.54	1.51
6 x 5	1.61	1.71	1.66	1.51	1.57	1.54
5 x 2	1.49	1.55	1.52	1.42	1.45	1.43
5 x 3	1.53	1.60	1.57	1.44	1.48	1.46
5 x 4	1.56	1.64	1.60	1.47	1.52	1.49
5 x 5	1.59	1.69	1.64	1.49	1.55	1.52
6 x 6	1.63	1.73	1.68	1.53	1.58	1.56
Mean	1.56	1.64		1.47	1.52	
	CD (0.05)			CD (0.05)		
	Spacing	0.02		Spacing	0.01	
	Pruning	0.01		Pruning	0.00	
	Spacing x Pruning	NS		Spacing x Pruning	0.01	

Maximum mean leaf nitrogen content (1.68 %) was found in trees spaced at 6×6 m which was significantly higher than all other spacings and minimum (1.52%) was recorded in trees spaced at 5×2 m. The leaf nitrogen content was also significantly affected by the pruning

levels. Leaf nitrogen content 1.64 per cent was found in pruned trees than 1.56 percent in un-pruned trees. The interaction between the spacing and pruning was found non significant.

The leaf nitrogen content was significantly increased with increasing the plant spacing and pruning levels during the winter season. Maximum (1.56 %) mean leaf nitrogen content was recorded in trees spaced at 6×6 m than other trees spaced at 6×5 m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3 m, 6×2 m and minimum (1.43 %) in trees spaced at 5×2 m. Pruning effect also found significant. The mean leaf nitrogen 1.52 per cent was recorded in pruned trees and 1.47 per cent was found in un-pruned trees. The interaction between the spacing and pruning was found significant. Maximum leaf nitrogen content (1.58 %) was observed in wider spacing of pruned trees as compared to all other spacing of pruned and un-pruned trees, whereas, minimum (1.42 %) was recorded in closer spacing of un-pruned trees.

4.6.2 Phosphorus

The data shown in table 45 clearly indicates that leaf P content was significantly affected by plant spacing and pruning levels during the rainy season. Phosphorus content of leaf significantly increased with increasing spacing. Mean phosphorus content of leaf was recorded significantly higher (0.28%) in trees spaced at 6×6 m which was at par with 6 ×5 m spacing and minimum was recorded (0.18 %) in trees spaced at 5×2 m. The leaf phosphorus content was also significantly affected by the pruning treatments. Leaf phosphorus content was observed significantly more (0.27 %) in pruned trees than (0.19 %) un-pruned trees. The interaction between the spacing and pruning was found non significant.

Table 45: Effect of spacing and pruning on the phosphorus content (%) in leaves of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	0.16	0.23	0.20	0.12	0.15	0.14
6 x 3	0.18	0.26	0.22	0.14	0.19	0.17
6 x 4	0.21	0.28	0.24	0.17	0.22	0.19
6 x 5	0.23	0.30	0.27	0.19	0.25	0.22
5 x 2	0.14	0.22	0.18	0.11	0.14	0.13
5 x 3	0.16	0.25	0.20	0.13	0.17	0.15
5 x 4	0.19	0.25	0.22	0.15	0.20	0.18
5 x 5	0.22	0.29	0.26	0.18	0.23	0.20
6 x 6	0.24	0.32	0.28	0.21	0.26	0.24
Mean	0.19	0.27		0.16	0.20	
	CD (0.05)			CD (0.05)		
	Spacing	0.01		Spacing	0.01	
	Pruning	0.01		Pruning	0.01	
	Spacing x Pruning	NS		Spacing x Pruning	NS	

The leaf phosphorus content was significantly increased with increasing the plant spacing and pruning levels during the winter season. Maximum (0.24 %) mean leaf phosphorus content was recorded in trees spaced at 6×6 m than other trees spaced at 6 ×5m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3m, 6×2 m and minimum (0.13 %) was observed in trees spaced at 5×2 m. Pruning effect also found significant. The mean leaf phosphorus content 0.20 per cent was recorded in pruned trees and 0.16 per cent was noticed in un-pruned trees. The interaction between the spacing and pruning showed non significant effect for phosphorus content in leaves.

4.6.3 Potassium

Data on leaf K content during the rainy and winter season presented in table 46 clearly reveals that the leaf potassium content was significantly increased with increasing spacing and pruning levels during the rainy season. Maximum mean leaf potassium content (1.28 %) was found in trees spaced at 6×6 m than other spacing at 6 ×5m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3m, 6×2 m and minimum (1.18 %) was registered in trees spaced at 5×2 m. Pruning effect also found significant. Leaf nitrogen content was found significantly more (1.25%) in pruned trees as compare to (1.20 %) un-pruned trees. The interaction effect between the spacing and pruning was statistically found non significant.

Table 46: Effect of spacing and pruning on the potassium content (%) in leaves of guava cv. Hisar Safeda

Spacing (m)	Rainy season			Winter season		
	Pruning			Pruning		
	Non pruned	Pruned	Mean	Non pruned	Pruned	Mean
6 x 2	1.16	1.21	1.19	1.09	1.13	1.11
6 x 3	1.18	1.23	1.21	1.11	1.16	1.13
6 x 4	1.21	1.26	1.24	1.13	1.19	1.16
6 x 5	1.23	1.29	1.26	1.16	1.22	1.19
5 x 2	1.15	1.20	1.18	1.08	1.11	1.09
5 x 3	1.17	1.22	1.20	1.10	1.14	1.12
5 x 4	1.20	1.25	1.22	1.12	1.17	1.15
5 x 5	1.22	1.27	1.25	1.15	1.20	1.18
6 x 6	1.25	1.32	1.28	1.18	1.23	1.21
Mean	1.20	1.25		1.12	1.17	
	CD (0.05) Spacing 0.01 Pruning 0.01 Spacing x Pruning NS			CD (0.05) Spacing 0.01 Pruning 0.00 Spacing x Pruning NS		

It was also observed that the leaf potassium content was significantly increased with decreasing planting density and increasing pruning levels during the winter season (Table 46). Maximum mean leaf potassium content (1.21 %) was recorded in trees spaced at 6×6 m than

other trees spaced at 6 ×5m, 5×5 m, 6×4 m, 5×4 m, 6×3 m, 5×3m, 6×2 m and minimum (1.09 %) was observed in trees spaced at 5×2 m. Pruning also significantly affected the leaf potassium content. The mean leaf potassium content 1.17 per cent was recorded in pruned trees and 1.12 per cent was registered in un-pruned trees. The interaction between the spacing and pruning showed the non significant effect for potassium content in leaves.

The findings of present investigation entitled “studies on canopy management in high density planting of guava (*Psidium guajava* L.)” is discussed in this chapter. During this investigation effect of different spacings viz, 6×2 m, 6×3 m, 6×4 m, 6×5 m, 5×2 m, 5×3 m, 5×4 m, 5×5 m, 6×6 m and pruning levels with no pruning and pruning of 50 per cent of last season shoot growth on solar radiation interception, microclimate factors (canopy temperature and relative humidity), chlorophyll fluorescence, plant growth characters, flowering characters, fruit yield, quality characters and leaf NPK content were studied during this course of investigation. The data on solar radiation interception, canopy temperature, relative humidity and chlorophyll fluorescence were recorded to estimate the photosynthesis rate of plants and its effect on fruit yield and quality parameters. The data related to the present study are discussed under the following heads:

5.1 Effect of spacing, pruning and different canopy part on solar radiation interception, microclimate parameter (canopy temperature and relative humidity) and chlorophyll fluorescence.

5.1.1 Solar radiation interception

Solar radiation interception was significantly increased with increasing the plant spacing during the rainy season (April- September). Maximum solar radiation interception was recorded in trees spaced at 6×6 m and minimum was recorded in trees spaced at 5×2 m. The possible explanation of this may be due to the fact of larger canopy volume more spreading branches and more number of leaves in the 6 ×6 m spaced trees. This result was in consonance with the findings of Singh (2001) reported in guava that maximum radiation interception in the trees spaced at 6x6 m than the trees spaced at 3x3 m, both trained to the modified leader system. Similar results have been reported by Singh and Dhaliwal (2007) in guava that radiation interception by the plants was increased with increasing the planting distance. Singh *et al.*(2007) revealed in guava that better light penetration and canopy temperature were observed in the trees planted at 6×6 and 3×6 m than the other distances (3×3 and 3×1.5m) at NS/EW canopy edge. These findings are in agreement with those of Brar *et al.* (2009) and Brar *et al.* (2013) in guava.

Pruning effect was also found significant. Maximum solar radiation intercepted by the pruned trees as compare to un-pruned trees. Similar result has been reported by Morgon *et al.* (1984) that photosynthetic photon flux density (PPFD) penetration was increased in summer pruned trees of guava. The different part of tree canopy also had a significant effect. Solar radiation interception was found significantly higher in upper part of tree canopy as compare to

middle and lower part of tree canopy. Likewise, Jackson (1970) also found more rapid decline in light levels with the depth of tree canopy in apple.

Microclimate parameter (canopy temperature and relative humidity)

5.1.2 Canopy temperature

The mean canopy temperature was significantly increased with increasing the plant spacing during the rainy and winter seasons. Highest mean canopy temperature was observed in plants spaced at 6×6 m and lowest mean canopy temperature was recorded in trees spaced at 5×2 m during both rainy and winter season. Mean canopy temperature was found significantly higher in upper part of tree canopy than middle and lower canopy part of canopy. Mean canopy temperature was found higher in pruned trees and lower in un-pruned trees. The mean canopy temperature during the winter season (September- February) was lesser than the mean canopy temperature of rainy season (April to September).

Higher temperature in plant at wider spacing and in pruned trees might be due to higher solar radiation interception and lesser relative humidity due to more hot air circulation which leads to increase in temperature. Canopy temperature of un-pruned trees was found lower than the pruned trees which might be due to dense canopy and higher transpiration rate which lower down the temperature in un-pruned trees. There is an increase in canopy temperature with increasing the spacings. Similar findings were also observed by Singh (2003), Singh and Dhaliwal (2007) Singh *et al.* (2007), Brar *et al.* (2013) in guava. Singh and Singh (2007) reported that canopy temperature was recorded maximum at 2.0 m pruning height and minimum in un-pruned guava trees.

5.1.3 Relative humidity

The mean relative humidity decreased with increasing the spacing and pruning levels and depth of plant canopy during the both the seasons. The relative humidity decreased with decreasing the planting density. Relative humidity recorded lesser in upper and middle part of tree canopy than lower part of tree canopy. Relative humidity increased with decreasing plant density might be due to high temperature, more solar radiation interception and more circulation of air leading to decrease the relative humidity.

Similarly, Singh and Dhaliwal (2007), Brar *et al.* (2009) and Brar *et al.* (2013) reported in guava that highest average relative humidity was found with closest spacing.

Higher relative humidity was recorded in un-pruned trees as compare to pruned trees during the both rainy (April to August) and winter (September to February) season. More relative humidity in un-pruned trees might be due to the fact that trees had dense foliage resulting in greater shading leading to reduction in temperature and lower solar radiation interception and higher transpiration rate occurs in dense canopy of un-pruned trees. Similar results have been reported by Sharma *et al.* (2001) in guava and Sharma and Singh (2006) in mango. They observed that denser canopy foliage and very poor light penetration in lower

part of tree canopy may be responsible for more relative humidity at lower part of tree canopy.

5.1.4 Chlorophyll fluorescence

Chlorophyll fluorescence was significantly increased with increasing the spacing and pruning level during the both rainy as well as winter season. Maximum mean chlorophyll fluorescence was recorded in trees spaced at 6×6 m and minimum in 5×2 m spacing during both the seasons.

Pruning effect also found significant. Mean chlorophyll fluorescence was found significantly higher in pruned trees and lesser in un-pruned trees during the both seasons. Chlorophyll fluorescence increased with increasing spacings and pruning levels may be due to high chlorophyll content was found with more spacing and pruned trees. Chlorophyll fluorescence increased with increasing the chlorophyll content in plants. Chlorophyll fluorescence was found higher in pruned trees than un-pruned trees. It may be due to younger leaves have more chlorophyll content than older leaves. Similar findings were reported by Tucker *et al.*, (1993) observed that chlorophyll fluorescence was influenced by the reductions in chlorophyll content and chlorophyllase activity in ripe and senescence fruits. Smillie *et al.*, (1987) reported that the decline in chlorophyll fluorescence during the ripening of banana and mango was associated with loss of chlorophyll content and chloroplast competence.

5.2 Effect of spacing, pruning and different canopy part on the vegetative characters

5.2.1 Tree trunk cross sectional area

Tree trunk cross sectional area significantly increased with increasing the spacing. Maximum tree trunk cross sectional area was recorded in trees spaced at 6×6 m and minimum was observed in closet spacing at 5×2 m. Tree trunk cross sectional area was found maximum with widest spacing might be due to greater availability of photosynthates and more chlorophyll content in leaves at widest spacing trees. It is also justified by the greater availability of photosynthates going in reserve tissues of the plant at widest spacing Kundu (2007) in guava. Similar results were reported by Pandey *et al.* (1997), Singh and Bal (2002) and Bal and Dhaliwal (2003) in guava. Pruning effect was also found significant. Tree trunk cross sectional area was found more in pruned as compare to un-pruned trees. This might be due to quick response to supplied food material absorbed by the roots and it transmitted to the main trunk of such trees. Moreover, in such trees most of the carbohydrates and nitrogen were utilized for the vegetative growth. These results are in concord with that Dhaliwal and Singh (2004) in guava.

5.2.2 Tree height

Tree height was significantly decreased with increasing the spacing. Tree height varied from 4.54 m to 3.18 m. Maximum height was recorded in trees spaced at 5×2 m and minimum in trees spaced at 6×6 m. The tree height was found maximum in un-pruned trees and minimum in pruned trees. Tree height was found maximum with closest spacing might be

due to greater competition for light. Widest spacing reduced plant height might be due to more availability of light and space than closest spacing. Tree height decreased with increasing the plant spacing (Singh *et al.*, 2007). Similar results have been reported by Kumar and Singh (2000), Kundu (2007), Bharad *et al.* (2012) in guava and Sharma *et al.* (1992) in Kinnow .

Un-pruned trees height was recorded more as compared to pruned trees. Lesser height of pruned trees might be due to the fact that trees were unable to make up the loss of growth due to pruning in short period of time. Kumar and Rattanpal (2010) also observed in guava that tree height reduced by removal of half of vegetative growth. Similar results obtained by Kumar and Dhaliwal (2001), Singh *et al.*, (2012) and Pratibha *et al.*, (2013) in guava.

5.2.3 Tree spread and canopy volume

Tree spread and canopy volume significantly increased with increasing plant spacing. Tree spread and canopy volume varied from 3.29 m to 4.96 m and 24.32 m³ to 42.55 m³. Maximum tree spread and canopy volume recorded in trees spaced at 6×6 m and minimum was observed in trees spaced at 5×2 m. Less spread and canopy volume was found in closer spacing might be due to competition between plants for light, nutrition, water and limitation of spacing . The results corroborate the finding of Singh *et al.* (2007) in guava. Similarly, Singh and Bal (2002) noticed in guava that maximum tree spread was found at wider spacing (6×6 m) in E-W direction and maximum mean tree volume was observed in plants at 6x5m spacing. Pal *et al.* (2016) reported in guava that canopy volume increased with increasing the plant spacings.

Pruning effect was found significant for both tree spread and canopy volume. Mean tree spread and canopy volume value were found significantly more in un-pruned trees than the mean tree spread and mean canopy volume were recorded in pruned trees. Lesser tree spread and canopy volume in pruned trees might be due to the fact that trees were unable to make up the loss of growth due to pruning in short period of time.

Similar results have been reported by Kumar and Rattanpal (2010), Singh *et al.* (2012), Prathiba *et al.* (2013) in guava and Lal and Mishra (2008) in mango.

5.2.4 Shoot length

Shoot length significantly increased with increasing the spacing and pruning levels. Maximum mean shoot length was recorded in trees spaced at 6×6 m and minimum was observed in trees spaced at 5×2 m. Shoot length found more at widest spacing might be due to more availability of light, nutrients and space helpful for increment of shoot length.

Mean shoot length was found higher in pruned trees might be due to reserve food materials in main branches helpful to increase the length of new shoots which were emerged after pruning. Similar finding were observed by Mohammed *et al.* (2006) in guava that pruning at 60 cm resulted in maximum shoot length during rainy and winter season. Similar results have been reported by Meena *et al.* (2016) in guava and Kumar *et al.* (2014) in ber.

5.2.5 Chlorophyll 'a' and 'b' content of leaves

Chlorophyll 'a' and 'b' content of leaves was significantly increased with increasing the spacing and pruning levels. Chlorophyll 'a' and 'b' content of leaves was found significantly higher in widest spacing (6×6 m) and pruned trees which might be due to more availability of light and nutrients by the plants and leaves that were found more greener in widest spacing plants. Similarly, Mirza *et al.* (2013) reported that chlorophyll is an antioxidant compound which is present and stored in chloroplast of leaf plant especially present in the green area of leaves. More chlorophyll 'a' and 'b' content found in pruned trees might be due to chlorophyll content was more in young leaves than old leaves. Similarly Kamble *et al.* (2015) observed in guava that chlorophyll a (chl.a) and chlorophyll b (chl. b) content was found higher in younger leaves than adult leaves. Richardson (2002) revealed that the chlorophyll a and chlorophyll b are essential pigment of the photosystems. Chlorophyll a is the primary photosynthetic pigment in plants which helps to produce energy in plant (Srichaikul *et al.*, 2011).

5.2.6 Leaf area and leaf area index

Leaf area and leaf area index was found significantly increased with increasing planting density during the both the seasons. Maximum leaf area and leaf area index was observed in trees spaced at 5×2 m and minimum was recorded in trees spaced at 6×6 m. Maximum leaf area found in closest spacing trees might be due to the competition for light and aeration which leads to increased leaf area by the plant. Pruning effect was also found significant. Leaf area was found more in un-pruned trees as compared to pruned trees. While, leaf area index was found more in pruned trees in comparison to un-pruned trees. This might be due to the fact that un-pruned trees have dense canopy and there was no proper penetration of light and aeration. For competition of light and aeration plants may increased their leaf surface. While pruned tree leaves were not enough mature as compared to pruned trees so plant is more exposed to sun light, accumulates more photosynthates and develop more number of leaves. Similarly Kumawat *et al.* (2014) revealed that in guava maximum leaf area (97.16 cm²) was recorded under 2.0 x 2.0 spacing and minimum under 1.0 x 1.5 spacing and maximum (3.29) leaf area index (LAI) was found under 1.0 x 1.5 and minimum under 2.0 x 2.0 spacing.

5.3 Effect of spacing, pruning and part of canopy on flower and fruit character of guava

5.3.1 Duration of flowering

Duration of flowering in guava was not significantly affected by spacing during the rainy season, While during winter season duration of flowering significantly affected by spacing. Longest duration of flowering was recorded in trees spaced at 5×2 m as compared to other spacings. Pruning effect also found significant. Longest duration of flowering was recorded in un-pruned trees as compared to pruned trees. Shortest duration of flowering was observed in widest spacing and pruned trees which might be due to more exposure of sun

light, more availability of nutrients and aeration that promotes early initiation of flowering and end of flowering. Similar result has been observed by Singh *et al.* (2010) in mango that pruning intensity at moderate level in high density planting took lowest number of days to 50 per cent of flowering, highest number of panicles per branch and longest blooming period. This result is conformity with earlier reported by Adhikari and Kandel (2015).

5.3.2 Flower bud density

Flower bud density was significantly increased with increasing spacing during both rainy and winter seasons. Maximum flower bud density was recorded in widest spacing (6×6 m) trees as than closest (5×2 m) spacing. This might be due to more canopy volume, light penetration and aeration that promote more number of flowering in plants. The results corroborate the findings of Mika *et al.*, (1981) in apple and Ristevski (1982) in pear.

Maximum flower bud density was recorded in un-pruned trees during rainy season, while higher flower bud density was noticed in pruned trees during winter season. This might be due to that April pruning reduced flower bearing shoots in rainy season and promote new shoot growth, which increases the flowering percentage in winter season. Similar results have been observed by pruning from April to June increased the flowering percentage of guava trees as compared to February and March pruning (Singh *et al.*, 2001). Jadhav *et al.*, (2002) observed in guava and that maximum flower per shoot were found during winter season with 60 cm pruning treatment. Mohammed *et al.* (2006) revealed in guava that the 60 cm pruning gave maximum number of flowers and fruits per shoot during winter season. The results are in concord with that of Pilania *et al.* (2010), Mehta *et al.*, (2012) and Prabhakar *et al.* (2016) in guava.

Part of canopy also significantly affected the flower bud density in plant during rainy and winter season . Flower bud density was found significantly higher in upper part of canopy in comparison to middle and lower part of canopy. This might be due to more solar radiation intercepted by the upper part of tree canopy. Whereas, minimum flower bud density found in lower part of canopy might be due to reduced radiation penetration in lower part of tree canopy. The results corroborate the findings of Deidda *et al.*, (1988) in citrus.

5.3.3 Fruit set

Fruit set per cent was significantly increased with the increasing spacings during both the seasons. Maximum fruit set per cent was observed in widest spacing trees in comparison to closest spacings. Maximum fruit set per cent found in widest spacing might be due to more spread and canopy volume of trees in the wider spacing which allowed more light and air to enter inside the canopy thereby creating a congenial microclimate within the tree canopy leading to high fruit-set. Pruning effect was also found significant during both rainy and winter season. Maximum fruit set per cent was recorded in un-pruned trees as compared to pruned tree during rainy season, whereas maximum fruit set per cent was recorded in pruned trees. This might be due to the fact that April pruning reduced the flower bearing

shoots in the rainy season resulting in a lower number of flowers and fruit set whereas, fruit set was found maximum in pruned trees in winter season due to the fact that the plant accumulates food reserve during rainy season which was diverted for the development of more fruits during winter season. These results are in agreement with earlier works carried out by Dhaliwal *et al.*, (2000), Dalal *et al.* (2004) and Pratibha *et al.* (2013) in guava. The interaction between spacing and pruning was found significant during both the seasons.

Part of canopy was also significantly affected the fruit set per cent during rainy and winter seasons. Fruit set per cent was found significantly higher in upper part of tree canopy as compare to middle and lower canopy during both the seasons. The low fruit-set in the inner parts of tree canopy might be due to more shade, adversely affecting the process of photosynthesis and reducing the availability of photosynthates.

5.3.4 Fruit retention and fruit drop

Fruit retention per cent was increased with the increasing spacing and fruit drop per cent decreased with the increasing spacing during both. Maximum fruit retention and minimum fruit drop per cent was found in trees spaced at 6×6 m as compared to all other spacings. Whereas, minimum fruit retention and maximum fruit drop was recorded in trees spaced at 5×2 m. The lesser fruit retention and more fruit drop per cent were found in the closer (5×2 m) spacing might be due to the greater competition for photosynthates among the developing fruits.

Maximum fruit retention and minimum fruit drop were recorded in pruned trees as compare to un-pruned trees during both the seasons. Less fruit retention and more fruit drop was found in un-pruned trees might be due to competition among fruitlets for carbohydrates, water, nutrients, hormones and other metabolites. These findings are confirmed to the findings of Sahay and Singh (2001) who reported that average fruit drop was found (12.10 %) in April month of pruning in guava. Vitagliano *et al.* (2001) reported in peach that fruit abscission was reduced by pruning. Brar *et al.* (2007) observed in guava that the increasing pruning intensity increased the fruit set and decreased fruit drop per cent. Similar result has been reported by Dhaliwal *et al.*, (2000) in guava.

Part of canopy was also significantly affected the fruit retention and fruit drop percent during rainy and winter season. Maximum fruit retention and minimum fruit drop was recorded in upper part of tree canopy as compare to other middle and lower part of tree canopy. Whereas, less fruit retention and maximum fruit drop found in the lower parts of the tree canopy might be due to severe competition for carbohydrates leads the reduction of auxin level in fruits and increased fruit drop per cent.

5.4 Effect of spacing, pruning and part of canopy yield parameter of guava

5.4.1 Number of fruits per tree

There was marked increment in number of fruits per tree with increasing the plant spacing during the both the seasons rainy as well as winter. Maximum number of fruits per

tree was found in trees spaced at 6×6 m as compared to all other spacings. The increasing number of fruits per tree in widest spacing might be due to larger canopy volume and larger canopy provide more fruit bearing area to the plant. More number of flower bud densities at 6×6 m spacing also might be the reason of more number of fruits per tree. Less number of fruits per tree were obtained in the close planting due to the shading effect of plant. Similar results have been reported by Mishra and Pathak (1998), Mohammed *et al.* (2006) and Brar *et al.* (2007) in guava.

Number of fruits per tree was also significantly affected by the pruning treatments during both the seasons. Shoot pruning of 50 per cent of last season growth in April significantly decreased the number of fruits per tree during the rainy season and increased the number of fruits per tree during the winter season in pruned trees. Increase in number of fruits per tree in pruned trees during winter season might be due to the flowering was shifted in all April pruned trees. Removal of flowering shoots during rainy season and new shoots production of lateral month might be the reason of reducing the number of fruits/ tree during rainy season and increased the number of fruits per tree during winter season. Similarly Singh *et al.* (2001) noticed in guava that heavy crop load of rainy season shifted to the winter season due to the pruning. Sharma and Singh (2006) studied in mango and observed that highest number of fruited panicles appeared in moderately pruned mango trees and lowest in unpruned trees. Similar findings were reported by Singh *et al.* (2007) and Brar *et al.* (2007) in guava.

5.4.2 Fruit weight and fruit size

Fruit weight and size increased with increasing spacing and pruning level during the both rainy and winter season. Fruit weight and size was found maximum in trees spaced at 6×6 m spacing both the seasons. Maximum fruit weight and size found in widest spacing trees might be due to more solar radiation intercepted by the trees. Closely spaced trees fruit weight and size found lesser might be due to severe competition for metabolites among the trees. Fruit weight and size were recorded higher in fruits harvested from pruned trees as compared to unpruned trees. The increments of fruit weight and size in pruned trees might be due to the production of more leaves/ fruit ratio.

The interaction effect between spacing and pruning for fruit weight was found significant during both the seasons whereas, for fruit size was found non significant during both the seasons.

Fruit weight was also significantly affected by the different parts of tree canopy. Fruit weight was found significantly higher in upper part of canopy than middle and lower part of canopy during the both rainy and winter season. This is might be due to the fact that more solar radiation intercepted by the upper part of tree canopy which in turn had more efficient photosynthetic activities resulting in higher availability of net photosynthates which leads to increase fruit weight and size by the plant.

Similarly Singh *et al.* (2001) observed in guava that increase in number and area of leaves increases the amount of photosynthates that cause a significant increase in size and weight of fruit in the winter season. Sheikh and Rao (2002) conducted an experiment on pomegranate and found that the highest fruit diameter and fruit weight were noticed with severe pruning and 30 fruit load against mild pruning and 50 fruits load. Similar findings were observed by Gurudarshan and Dhaliwal (2004), Haropinder and Bal (2006) and Singh *et al.* (2010) in guava.

5.4.3 Yield per tree and yield per hectare

Yield per tree and yield per hectare were significantly affected by the planting densities and pruning levels during the both rainy as well as winter season. Yield per tree was significantly increased with increasing the spacings, while yield per hectare was significantly increased with increasing the plant density. Yield per tree found maximum widest spacing in plants might be due to more canopy volume and flower bud density as compared to closest spacing. Yield (tonnes per hectare) increased in closest spacing due to the more number of plants occupied in one hectare compared to widest spacing. Singh *et al.* (2008) obtained yield of 44.25 kg per plant and 49.16 tonnes per hectare in guava cv. Sardar under high density planting at 3 x 3 m spacing at the age of twelve years. Singh (2008) noticed that the production of guava in high density planting (1.5 m x 3.0 m) was 26 tonnes per hectare in the third year. The yield increased up to 47 tonnes per hectare in the fifth and 55 tonnes per hectare in the seventh year of growth. In the density of 6 x 6 m, the yield was 6 tonnes per hectare in the third year.

Yield per tree and yield per hectare were recorded more in un-pruned trees as compared to pruned trees during rainy season, while yield (kg/tree) and yield (tonnes per hectare) were observed significantly higher in pruned trees compare to un-pruned trees. Shoot pruning of 50% of last season growth in April significantly decreased yield (kg/tree) and yield (tonnes per hectare) during the rainy season and increased yield per plant and yield per hectare during the winter season in pruned trees. Increased yield per plant and yield per hectare in pruned trees during winter season might be due to the flowering was shifted in all April pruned trees. Removal of flowering shoots during rainy season and new shoots production of lateral month might be the reason of reducing the number of fruits per tree during rainy season and increased the number of fruits per tree during winter season. Similar results have been found by Sahar and Hameed (2013) observed in guava that number of fruits per tree, yield per tree and fruit weight better with apical 10 cm shoot pruning in May. Adhikari and Kandel (2015) revealed that in guava 20 cm shoot pruning 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. Similar results have been observed by Dubey *et al.* (2002), Kumar and Rattanpal (2010), Adhikari and Kandel and Prakash *et al.* (2012) in guava.

5.4.4 Fruiting density and yield efficiency

Fruiting density was not significantly affected by spacing and pruning treatments during both rainy and winter season. Maximum fruiting density and yield efficiency were recorded in trees spaced at 6 x 6 m during rainy season whereas maximum fruiting density was found at 6x4 m and maximum yield efficiency at 6 x 6 m during winter season. Pruning effect was also found non significant during rainy season and significant effect was found during winter season. Fruiting density was found maximum in pruned trees as compare to un-pruned trees. This might be due to April shoot pruning shifted the rainy season crop load to the winter season and increases the number of fruits per tree. Similar findings were recorded by Singh *et al.* (2001) and Brar *et al.* (2007) in guava and Sharma and Singh (2006) in mango.

Yield efficiency was found significantly increased with increasing the spacing and pruning levels during rainy and winter season. Yield efficiency was found significantly higher in trees spaced at 6x6 m during both the seasons rainy and winter. The increment of yield efficiency under wider spacing might be due to more canopy volume, flower bud density and more fruit bearing area on larger canopies during both the seasons. These results are in conformity with the finding of Lal *et al.* (2000), Kundu (2007), Singh *et al.* (2007) and Brar *et al.* (2013) in guava.

Pruning effect was found significant for the both seasons rainy and winter. Yield efficiency was recorded maximum in un-pruned trees as compare to pruned trees during the rainy season, while maximum yield efficiency was found in pruned trees and minimum in un-pruned trees during the winter season. This might be due to 50 per cent shoot in pruning in April shifted the rainy season crop load to the winter season and increased yield per tree during the winter season. The findings are in agreement with those of Dubey *et al.* (2002), Kumar and Rattanpal (2010), Sahar and Hameed (2014), Adhikari and Kandel (2015) and Prakash *et al.* (2012) in guava.

5.5 Effect of spacing, pruning and part of canopy on quality characters of guava

5.5.1 Firmness, total soluble solids, total sugar and ascorbic acid

Plant spacing was significantly affected the fruit quality in term of firmness, TSS, total sugar and ascorbic acid content. Fruit firmness, TSS, total sugar and ascorbic acid content in fruits were significantly increased with increasing spacing during the both seasons rainy and winter. Fruit firmness, TSS, total sugar and ascorbic acid content recorded maximum in fruits harvested from widest spaced trees at 6×6 m as compared to all other spacings during the both crop season rainy and winter. This might be due to more light penetration, nutrient availability, more aeration and moisture availability which leads to increased firmness, TSS, total sugar and ascorbic acid content in fruits. The increased total sugar content in fruit might be due to the effect of high temperature received during flowering and fruit formation and at the time of fruit ripening and also due to the fact of degradation of

polysaccharides into simple sugars by metabolic activities, conversion of organic acids into sugars and loss of moisture as stated by Lakpathi *et al.* (2013). Similar result has been reported by Singh and Bal (2002) observed in guava that maximum fruit TSS content was found in fruits harvested from widest spacing trees. Singh and Dhaliwal (2004) reported in guava that quality increased in terms of TSS and total sugar in the fruits harvested from the trees spaced at 6 x 6 m than the fruits harvested from 6x4 m and 6x5 m spacing.

Pruning effect also found significant during the rainy and winter season. Fruit TSS content was found significantly higher in fruits harvested from pruned trees compared to unpruned trees during the both seasons. This is might be due to that the pruned trees had more number of leaves to fruit ratio and accumulation of more metabolites as compare to un-pruned trees which leads to increased fruit quality in terms of fruit firmness, TSS, total sugar and ascorbic acid content. Similar findings have been noticed by Kumar and Rattanpal (2010) studied in guava and observed that TSS and vitamin C content was found best with the pruning treatment by 1/2 removal of vegetative growth at 6x4 spacing. Singh (2011) found that pruning treatment increased the vitamin C of harvested fruits from different planting densities. Prakash *et al.* (2012) reported in guava that moderately pruned trees gave highest ascorbic acid content of fruits in winter season. Bhagawati *et al.* (2015) reported in guava that TSS of fruits was found to increase with enhanced pruning severity and lowest in case of no pruning treatment. Jayswal *et al.* (2017) studied in guava and observed that maximum (241.0mg/100g) ascorbic acid and (8.07%) total sugar were found with pruning at 40 cm and minimum in un-pruned plants. These findings are in agreement with the results obtained by the investigations of Dubey *et al* (2001), Tahir and Kamran (2002), Dhaliwal and Kaur (2003), Kindo (2005), Mohsen, A. T. (2010), Sahar and Hameed (2014) and Adhikhari and Kandel (2015), Sah (2013), Suresh and Shakila (2017) in guava and Jens *et al.* (2005) in apple.

Part of canopy also significantly affected the fruit quality in terms of firmness, TSS, total sugar and ascorbic acid during the both rainy and winter season. Fruit firmness, TSS, total sugar and ascorbic acid content of were found significantly higher in fruits harvested from upper part of tree canopy as compared to fruits harvested from middle and lower part of tree canopy. Fruit quality viz firmness, TSS, total sugar and ascorbic acid content were found less in middle and lower part of canopy due to rapid decline in the radiation penetration and aeration with depth of canopy thus adversely affected the process of photosynthesis.

5.5.2 Titratable acidity

Acid content of fruit significantly decreased with the increasing spacing and pruning level during the both rainy and winter seasons. Acid content was found more in fruit harvested from closely spaced trees as compared to fruit harvest from widest spacing. Acid content was found significantly higher in fruits harvested from closely spaced at 5x2 m.

Pruning effect was found significant during both rainy and winter season. Acid content was found more in fruits harvested from un-pruned trees as compared to fruits harvested from pruned trees. This might be due to availability of more leaves per fruit as compare to un-pruned trees, which synthesize and diverted more carbohydrate to developing fruits. Similar findings have been reported by Dubey *et al.* (2001) and Tahir and Kamran (2002) and Bhagawati *et al.* (2015) in guava. The increase titratable acidity in un-pruned plants is due to lower rate of reduction of starch to sugars more competition for nutrients, moisture and unavailability of light (Mahadevan and Kumar 2014). This result is conformity with earlier reported by Sahay and Singh (2001).

Effect of different canopy part on fruit acid content was also found significant during both rainy and winter season. Acid content of was recorded significantly higher in fruits harvested from lower part of canopy as compare to fruits harvested from middle and upper part of canopy. Maximum acid content found in fruits harvested from lower part of canopy might be due to shading effect and low temperature and lack of aeration which increased the acid content of fruit.

5.6: Effect of spacing and pruning on the NPK content of leaves

NPK content of leaves significantly increased with increasing the spacing and pruning level during rainy and winter seasons. NPK content of leaves was found maximum in widest spacing trees at 6x6 m and minimum was recorded in closest spacing at 5x2 m. NPK content of leaves found less in closest spacing of plant might be due to more competition among the plants for nutrients and water leads less availability of nutrients to the plants, whereas more availability of nutrients to the plant in widest spacing. Pruning effect was also found significant. Maximum leaves NPK was found in pruned trees and minimum in un-pruned trees. It might be due to pruning reduces the crop loads and plant part more exposed to sun light which provides more photosynthates and nutrients to the plants as compared to un-pruned trees. Similarly Adhikari (2009) reported in guava that highest NPK content of leaves found with increasing pruning severity. Singh *et al.* (2017) observed that in guava highest N, P and K content of leaves observed on the plants which was 60% shoot pruned. These results are in agreement with the findings of Lal *et al.* (2000) in guava.

The present investigation entitled “**Studies on canopy management in high density planting of guava (*Psidium guajava* L.)**” was conducted in experimental orchard and the chemical analysis was undertaken in the laboratory of the Department of Horticulture, Plant Physiology and Soil Science, CCS Haryana Agricultural University, Hisar during the rainy and winter season of the year 2016-2017. The experimental findings are summarized below:

1. In the present study, solar radiation interception was found significantly higher with increasing the spacings and pruning levels during the rainy season. It was also observed that pruned trees intercepted more solar radiation in comparison to un-pruned trees. Upper part of canopy significantly intercepted more solar radiation in comparison to middle and lower part of canopy.
2. Canopy temperature and chlorophyll fluorescence was significantly increased whereas, relative humidity decreased with increasing the plant spacings and pruning levels. Maximum canopy temperature, chlorophyll fluorescence and minimum relative humidity was recorded in trees spaced at 6×6 m contrary to this, minimum canopy temperature, chlorophyll fluorescence and maximum relative humidity was found in trees spaced at 5×2 m during both the seasons. Maximum mean canopy temperature and minimum mean relative humidity was recorded in upper part of canopy as compared to middle and lower part of canopy.
3. The results indicated that plant growth characters like tree trunk cross sectional area, tree height, tree spread, canopy volume, shoot length and chlorophyll ‘a’ and ‘b’ content in leaves were significantly affected by the plant spacings and pruning levels. Maximum trunk cross sectional area, tree spread, canopy volume, shoot length, chlorophyll ‘a’ and ‘b’ content in leaves and lesser tree height were recorded in widest spacing at 6×6 m and pruned trees in comparison to closer spacing (5×2 m) and un-pruned trees.
4. Leaf area and leaf area index were found significantly more in closest spacing (5× 2 m) and un-pruned trees as compared to wider spacing (6× 6 m) and pruned trees during both the seasons.
5. Longest duration of flowering was recorded in closest spaced trees at 5×2 m. Shortest duration of flowering was recorded in pruned trees as compared to un-pruned trees during rainy as well as winter season.

6. Early full bloom and end of flowering was recorded in wider spaced trees at 6×6 m as compared to trees spaced at 5×2 m. Delayed full bloom and end of flowering was recorded in pruned trees as compared to un-pruned trees during rainy season, whereas, during winter season early full bloom and end of flowering was observed in pruned trees as compared to un-pruned trees.
7. Maximum flower bud density was noticed in widest spaced trees (6×6 m). Flower bud density was found more in un-pruned trees in comparison to pruned trees during rainy season while it was maximum in pruned trees during the winter season. Flower bud density was recorded maximum in upper part of canopy as compared to middle and lower part of canopy during both the seasons.
8. Fruit set was observed more in widest spaced (6×6 m) trees as compared to closest spacing (5×2 m). Fruit set percentage was found more in un-pruned trees. Fruit set percentage was recorded higher in upper part of canopy as compared to other part of canopy during both the seasons.
9. Maximum fruit retention and minimum fruit drop was recorded in widest spacing (6×6 m) and pruned trees. Upper part of canopy significantly recorded higher fruit set with minimum fruit retention as compared to other part of canopy during rainy and winter season.
10. Maximum number of fruits per tree, fruit weight, fruit size and yield per tree was recorded in widest spaced trees at 6×6 m during both the seasons. Maximum number of fruits per tree and yield per tree were recorded in un-pruned trees during rainy season, whereas, during winter season maximum number of fruits per tree and yield per tree were enjoyed in pruned trees. Fruit weight, fruit length and fruit breadth were found maximum in pruned trees during both the seasons. Parts of canopy also significantly affected the fruit weight. Fruit weight was found maximum harvested from the upper part of tree canopy as compared to middle and lower part of canopy during rainy and winter season.
11. Maximum yield per hectare was found in closest spacing trees (5×2 m) and minimum was recorded in widest spacing trees (6×6 m) during both the seasons. In un-pruned trees maximum yield per hectare was recorded as compared to pruned trees during rainy season, while during winter season maximum yield was recorded in pruned trees than un-pruned trees.
12. Spacing and pruning could not bring any significant variation in fruiting density. During rainy season fruiting density was recorded maximum in un-pruned trees, while, fruiting density was found significantly higher in pruned trees during winter season.

13. Yield efficiency was found significantly higher in widest spacing (6×6 m) and it is also recorded that pruned trees had significantly higher yield efficiency as compared to un-pruned trees during both the seasons.
14. Fruit firmness, TSS, total sugar and ascorbic acid content were found significantly higher and acidity was lower in fruits harvested from widest spacing (6×6 m) trees during both the seasons. Maximum fruit firmness, TSS, total sugar and ascorbic acid content and minimum acidity were found in fruits harvested from pruned trees as compared to un-pruned trees during both the seasons.
15. Nitrogen, phosphorus and potassium content in leaves were significantly increased with increasing spacing and pruning levels during both the seasons. Highest nitrogen, phosphorus and potassium content were registered in trees spaced at 6×6 m. maximum NPK content in leaves is registered with pruned trees during both the seasons.

Conclusion

On the basis of the results summarized above, it can be concluded that pruning (shoot pruning of 50% of last season growth) was found most effective practice in high density planting of guava to manage the tree canopy based upon positive results of solar radiation interception, microclimatic factors of tree canopy (temperature and relative humidity) and chlorophyll fluorescence, effective management of plant growth parameters and vegetative character like tree trunk cross sectional area, tree height, spread, canopy volume and shoot length. Chlorophyll 'a' and 'b' content were found significantly higher in pruned trees. Maximum production and better quality of fruits was recorded in wider spacing (6×6 m) whereas, productivity was found significantly higher at closest spaced 5×2 m trees during both the seasons. Maximum flower bud density, fruit set, fruit retention, fruit weight, fruit size, fruit firmness, TSS, total sugars, ascorbic acid and lower acid was found in fruits harvested from upper part of canopy. Conclusively, it emerges that canopy management of guava by the shoot pruning of 50 per cent last season growth in April was found most effective to manage microclimatic factors (temperature and relative humidity), plant growth factors and increased the production, productivity and improve the fruit quality under high density planting.

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APPENDIX-I

Monthly meteorological data during the year 2016-2017

MONTH	MAX	MIN	GMIN	AVP	AVP	RH	RH	AVG	BRI	PAN	RAIN
	TEMP	TEMP	TEMP	(mm)	(mm)	(%)	(%)	WS	SUN	EVAP	FALL
	°C	°C	°C	M	E	M	E	KM/H	HRS	(mm)	(mm)
JAN	19.6	7.1	3.3	8.5	10.6	95	65	2.8	4.1	1.1	0.0
FEB	23.8	7.2	2.3	8.2	10.6	92	49	3.4	7.2	2.3	5.3
MAR	29.9	13.7	8.5	13.1	14.1	88	46	4.7	8.1	3.8	25.2
APR	37.9	18.4	0.0	13.6	12.3	61	25	4.7	8.6	6.8	0.0
MAY	41.0	24.8	0.0	18.9	18.6	63	35	7.4	8.1	9.1	44.3
JUN	39.6	27.6	0.0	23.3	22.0	71	44	8.1	7.8	7.2	91.1
JUL	35.1	26.1	0.0	26.7	26.8	90	72	5.5	5.9	4.8	244.8
AUG	34.0	25.6	0.0	26.0	25.8	90	69	5.9	6.0	4.2	80.4
SEP	35.2	24.2	0.0	22.6	22.6	86	54	5.0	8.8	4.8	2.8
OCT	34.6	18.4	0.0	16.8	16.6	84	42	2.9	7.8	3.9	12.0
NOV	29.4	11.1	0.0	10.4	14.3	92	48	1.7	5.1	1.9	0.0
DEC	25.9	7.8	2.4	9.0	12.5	95	51	1.9	7.0	1.5	0.0
JAN	18.6	6.9	1.7	8.5	11.2	99	71	3.5	4.1	1.1	41.2
FEB	24.3	7.8	3.5	8.9	10.2	92	46	2.7	7.7	2.1	0.0

ABSTRACT

Title of Thesis	:	Studies on canopy management in high density planting of guava (<i>Psidium guajava</i> L.)
Full Name of the Degree Holder	:	Anjali Tripathi
Admission Number	:	2012A27D
Title of the Degree	:	Doctor of Philosophy
Name of Discipline	:	Horticulture – Fruit science
Name and Address of Major Advisor	:	Dr. S. K. Sehrawat Director of Research CCS HAU, Hisar-125 004 (Haryana) India
Degree Awarding University	:	CCS Haryana Agricultural University Hisar-125 004 (Haryana), India
Year of Award of Degree	:	2018
Major Subject	:	Horticulture – Fruit science
Total Number of Pages in Thesis	:	95 + vii + I
Number of Words in Abstract	:	528
Keywords	:	Spacing, Pruning, Canopy and Guava

The present investigation entitled “Studies on canopy management in high density planting of guava (*Psidium guajava* L.)” was carried out at experimental orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2016-2017. The experiment was laid out in a Randomized Block Design (RBD) with 18 treatments *i.e.* nine different plant spacings 6×2 m, 6×3 m, 6×4 m, 6×5 m, 5×2 m, 5×3 m, 5×4 m, 5×5 m, 6×6 m and two levels of pruning no pruning and 50 per cent shoot pruning of last season growth. The present investigation clearly revealed that 50 per cent shoot pruning of last season growth under high density planting was effective practice to manage the plant canopy, increased yield per unit area and better the fruit quality. Findings revealed that solar radiation interception significantly increased with increasing the plant spacings and pruning levels. Similarly, with increase in plant spacing and pruning level, canopy temperature and chlorophyll fluorescence were increased whereas relative humidity decreased during both the seasons. Solar radiation interception and microclimate parameters (canopy temperature and relative humidity) were significantly affected by the different parts of tree canopy. Upper part of canopy intercepted more solar radiation and canopy temperature and minimum relative humidity was found in upper part of canopy as compared to all other part of canopy. Plant growth parameters like tree trunk cross sectional area, tree spread, canopy volume and shoot length were also found maximum in wider spacing (6×6 m) plant and minimum was found in closer spacing (5×2 m) and pruned trees, while maximum tree height recorded in closed spacing and non pruned trees and minimum tree height was observed in wider spacing (6×6 m) and pruned trees. Chlorophyll ‘a’ and ‘b’ content of leaf were found maximum in wider spacing (6×6 m) and pruned trees while maximum leaf area and leaf area index was recorded in closer spacing (5×2 m). Maximum fruit set, fruit retention percentage and minimum fruit drop were recorded in wider spacing (6×6 m) and pruned trees. Maximum flower bud density, number of fruits/tree, fruit weight and fruit size, yield/tree were also observed maximum in wider spacing (6×6 m) while yield per hectare (tonnes) was recorded maximum in closer spacing (5×2 m). Pruning was proved effective practice to increase the productivity during winter season. Fruit firmness, TSS, total sugar and ascorbic acid content of fruits was observed maximum in wider spacing (6×6 m) and pruned trees during both the seasons, whereas acidity content found minimum in fruits harvested from wider spacing (6×6 m) and pruned trees. Fruit firmness, TSS, total sugar and ascorbic acid content of fruits were found significantly higher in upper part of canopy as compared to middle and lower part of canopy during both the seasons. NPK content of leaf was observed maximum in wider spacing (6×6 m) and pruned trees. Thus 50% shoot pruning during April was found most effective practice to manage the microclimate factors, plant growth and increased the productivity of closer spacing trees (5×2 m) during winter season and improved the quality of fruits during both the seasons.

MAJOR ADVISOR

STUDENT'S SIGNATURE

HEAD OF THE DEPARTMENT

CURRICULUM VITAE

- (a) Name : **Anjali Tripathi**
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Degree	University/Board	Year of Passing	Percentage of marks	Subjects
M.Sc.	Uttarakhand University of Horticulture and Forestry, Bharsar	2014	80.05	Horticulture (Fruit Science)
B.Sc.(Hons.)	HNB Gharwal University, Srinagar	2012	77.20	Agriculture

Trainings

- Successfully completed of 90 hours Advance Computer Training held from 24th Jan- 23rd Feb 2017, organized by Student Counseling & Placement Cell, Directorate Students Welfare, CCSHAU, Hisar.
- Attended and successfully completed the training program in Protected Cultivation of Horticultural Crops held from 28th Oct - 6th November 2015, organized by Student Counseling & Placement Cell, CCSHAU, Hisar.

Conferences and Workshops

- Participated in the National Conference on "Hill Agriculture in Perspective (HAP-2016)" held at G.B. Pant University of Agriculture and Technology, Pantnagar.
- Poster presentation in National Conference on "Food Processing India 2017" held at Guru Jambheshwar University of Science and Technology, Hisar.
- Oral presentation in International Conference on Emerging Areas of Environmental Science and Engineering (EAESE-2017) held at Guru Jambheshwar University of Science and Technology, Hisar.
- Oral Presentation in International Conference on Advances in Agricultural and Biodiversity Conservation for Sustainable Development (ABCD-2017) held at CCS University Meerut, UP.
- Participated in 3rd International Young Scientist Congress (IYSC-2017) International Science Community Association held at Meshsana Urban Institute of Sciences, Ganpat University, Mehsana, Gujarat.
- Participated in the International Conference on Microbes for Health and Wealth 2017 held at Maharshi Dayanand University, Rohtak.
- Participated in Knowledge Workshop on Scientific Writing, e-Books and Publication Process organized by University Science Forum, Directorate of Human Resource Management, CCSHAU Hisar on 12th April, 2017.
- Participated in Workshop on Scientific Writing on 8th 9 May 2017 organized by International Science Community Association held at Mahsana Urban Institute of Sciences, Ganpat University, Mehsana, Gujarat, India.

List of Publications:

1. **Tripathi, A.**, Uniyal, S., Sajwan, P. and Negi, S. S. 2017. A review on impact of preharvest foliar sprays of macronutrients on yield and quality improvement of fruit crops. *Research Journal of Recent Sciences*, **6**(6): 43-56.
2. **Tripathi, A.** and Uniyal, S. 2018. Effect of preharvest foliar spray of nutrients on the quality improvement of apple (*Malus domestica* Borkh.) in Uttarakhand. *International Journal of Chemical Studies.*, **6**(2): 1990-1992.
3. **Tripathi, A.**, Sehrawat, S.K., Dahiya, D.S. and Kumar, N. 2017. Effect of canopy microclimate under different pruning treatments and planting densities in guava (*Psidium guajava* L.). International Conference on Emerging Areas of Environmental Science and Engineering on 16-17 February at Guru Jambheshwar University of Science and Technology, 149.

Anjali Tripathi

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