

Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. 'Sardar' under high density and traditional system of planting

1 ?ku ,oa ijEijkxr fof/k; ka }kjk vkjkfir ve: n
1/4I ft; e Xoktkok ,y-½ fdLe I jnkj dh of)] mit
,oa xqkoÙkk ij ikni of) fu; kedka dk çHkko

**Thesis
Submitted to the**

**Maharana Pratap University of Agriculture and Technology,
Udaipur**

for partial fulfilment of the degree of

**Doctor of Philosophy in Agriculture
(Horticulture)**



2005

By

MOOL CHAND JAIN

**Maharana Pratap University of Agriculture and Technology, Udaipur
Rajasthan College of Agriculture, Udaipur**

CERTIFICATE - I

Dated : / / 2005

This is to certify that **Mr. Mool Chand Jain** had successfully completed the Comprehensive/Preliminary Examination held on 13th June, 2003 as required under the regulation for **Ph.D. Degree**.

Dr. Shafaat Mohammed
Prof. and Head
Department of Horticulture
Rajasthan College of Agriculture
Udaipur – 313 001 (Rajasthan)

**Maharana Pratap University of Agriculture and Technology, Udaipur
Rajasthan College of Agriculture, Udaipur**

CERTIFICATE - II

Dated : / / 2005

This is to certify that the thesis entitled “**Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting**” submitted for the degree of **Doctor of Philosophy** in Agriculture in the subject of **Horticulture**, embodies bonafide research work carried out by **Mr. Mool Chand Jain** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on 11th Feb., **2005**.

Forwarded by

Dr. Shafaat Mohammed
Prof. and Head
Department of Horticulture

Dr. L. K. Dashora
Major Advisor

Dr. G. S. Sharma
Dean
Rajasthan College of Agriculture
Udaipur – 313 001 (Rajasthan)

**Maharana Pratap University of Agriculture and Technology, Udaipur
Rajasthan College of Agriculture, Udaipur**

CERTIFICATE - III

Dated : / /2005

This is to certify that the thesis entitled “**Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting**” submitted by **Mr. Mool Chand Jain** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfilment of the requirements for the degree of **Doctor of Philosophy** in Agriculture in the subject of **Horticulture**, after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory, we therefore, recommended that the thesis be approved.

Dr. L.K. Dashora
Major Advisor

Dr. Shafaat Mohammed
Advisor

Dr. Sudha Rani Mathur
Advisor

Dr. P.K. Dashora
Advisor

Dr. Shafaat Mohammed
Prof. and Head
Department of Horticulture

Dr. H.S. Purohit
DRI Nominee

Dean
Rajasthan Collage of Agriculture
Udaipur

(External Examiner)

APPROVED

(Dr. L.L. Somani)
Director

Resident Instructions

Maharana Pratap University of Agriculture and Technology, Udaipur

**Maharana Pratap University of Agriculture and Technology,
Udaipur
Rajasthan College of Agriculture, Udaipur**

CERTIFICATE - IV

Dated : / /2005

This is to certify that **Mool Chand Jain** student of Department of **Horticulture**, Rajasthan College of Agriculture, Udaipur has made all corrections/modifications in the thesis entitled “**Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting**” which were suggested by the external examiner and advisory committee in the oral examination held on / /2005. The final copies of the thesis duly bound and corrected were submitted on / /2005, are enclosed herewith for approval.

Dr. L.K. Dashora
Major Advisor

Enclosed : One original and two copies bound thesis forwarded to the Director, Resident Instructions through Dean, Rajasthan College of Agriculture, Udaipur.

Dr. Shafaat Mohammed
Prof. and Head
Department of Horticulture

Dean
Rajasthan College of Agriculture
Udaipur – 313 001 (Rajasthan)

1. INTRODUCTION

Guava (*Psidium guajava* L.) which belongs to family Myrtaceae is a native of tropical America though widely grown in the regions of tropical and sub-tropical part of India. Guava is a very common fruit, popular among the rich and poor alike due to its moderate price, nourishing value and good taste. The fruit is rich in Vit-C and pectin besides being a good source of thiamine and riboflavin.

It is the fourth most important tropical / sub-tropical fruit crops, after mango, banana and citrus both in area and production. It is known as 'apple of tropics' and can be grown in wide range of soil and climatic conditions. It occupied an area of 1.51 lakh ha with a total production of 18.0 lakh tonnes (Annon, 2003). The major guava growing pockets in India are Uttar Pradesh, Madhya Pradesh, Bihar, Karnataka, Gujarat, Andhra Pradesh, Tamilnadu, Maharashtra, West Bengal, Punjab, Orissa and Rajasthan.

Guava being hardy and with ability to grow under arid and semi-arid conditions is becoming most important fruit crops of Rajasthan state, where this fruit crop has a great potential throughout the state. At present in Rajasthan it is third most important fruit crop, which occupies an area of 1.6 thousand ha with a production of 23.7 thousand tonnes annually (Annon, 2003). The major guava growing districts in Rajasthan are Udaipur, Bundi, Kota, Baran, Ajmer, Chittorgarh, Swaimadhopur and Bhilwara. The increasing demand of guava as a commercial tropical fruit both for table and processing purpose demands, its widespread cultivation ensuring regular cropping and higher production. To meet out the increasing demand of this fruits, the chances of bringing sufficient area under this fruit crop is very less due to heavy population pressure and therefore, one of the alternatives is to increase the productivity and quality of the existing orchards with the use of plant growth regulators and other means.

At present, guava is cultivated largely through a traditional cultural practices and systems under which it is difficult to achieve desired level of production, because large tree provides low production per unit area and needs higher labour inputs. Moreover, some times this plant does not flower and fruits for longer time, which could further increases the overall cost of production. An overriding need exists either to improve the traditional system of cultivation or to develop new and modern system of cultivating guava to overcome the problems inherent with this tree. Chepman *et al.* (1979) and Singh *et al.* (1980) studied the application of high density planting for guava production and obtained encouraging results.

During the last 50 years considerable research work has been done in the country on various aspects such as varieties, propagation, irrigation, training and pruning etc. to increase the yield and quality of guava fruits. The production of poor quality fruits is a matter of common experience. It would be therefore worthwhile to improve the yield and quality of guava by foliar application of plant growth regulators. The use of plant growth regulators has assumed an integral part of modern crop husbandry for increasing production of quality fruits. The plant hormones or regulators are the organic chemical compounds, which modify or regulate physiological processes in an appreciable measure in the plant when used in small concentration. They are readily absorbed and move rapidly through the tissues, when applied to different plant parts. These chemicals are specific in their action. In other words, plant growth regulators are organic substances (other than nutrients), which in small amount promote, inhibit or otherwise modify any physiological process in plants. Thus the use of plant growth regulators has resulted in some outstanding achievements in several fruit crops with respect to growth, yield and quality. For examples, Yadav (1998) found that spray of 10 ppm NAA increased the fruit yield of guava and reduced the unmarketable fruits. Similarly, Singh *et al.* (2000) reported that spray of ethephon at the concentration of 1800 ppm given highest yield in guava over control.

The application of paclobutrazol increased the yield in mango (Singh, 2000 Subhadrabandhu *et al.*, 1999 and Vijayalakshmi and Srinivasan, 1990). Paclobutrazol reduces the vegetative growth like shoot length and number of leaves in order to improve tree productivity significantly over control in sultania cultivar of fig (Hussein *et al.*, 1998). Similarly in grape the spray of paclobutrazol increased berry set, bunch size, yield and quality in respect to T.S.S and acidity of fruit (Sherawat *et al.*, 1998). Early flowering and fruiting was also recorded by application of paclobutrazol in mango (Sao Jose and Rebounces, 2000). Similarly spray of CCC increased fruit yield in grapes (Sherawat *et al.*, 1998) like wise triacontanol at the concentration of 10 and 20 ppm increased fruit size and weight significantly in plum (Mahajan and Sharma, 1999).

In view of the above fact, it becomes quite clear that applications of plant growth regulators are very useful not only for increasing the yield, but also to improve the quality of fruits. However, no attempt yet seems to have been made on these aspects in guava in Rajasthan particularly under Udaipur agro-climatic conditions.

Thus, it was decided to conduct well-planned systematic field experiment entitled “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional systems of planting” at horticulture farm, Rajasthan College of Agriculture, Udaipur. For this purpose two sets of

experiments i.e. I. Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. 'Sardar' under high density planting system and

II. "Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. 'Sardar' under traditional systems of planting" were laid-out separately in the existing orchard with the following objectives.

1. To find out the effect of different plant growth regulators on growth, flowering, fruiting and yield of guava under high density and traditional system of planting.
2. To compare the efficacy of plant growth regulators on physico-chemical characteristic of guava fruits under high density and traditional systems of planting.
3. To determine best treatment for induction of flowering, fruiting, yield and quality of guava fruits under high density and traditional system of planting.
4. To test the economic feasibility of treatments used.

2. REVIEW OF LITERATURE

Under the advancing agriculture technology, application of plant growth regulators has become beneficial under different agro-climatic condition in various fruit crops. The plant growth regulators are applied in different fruits crops to increase yield and improve quality of produce by regulating the specific chemical processes in plants Weaver (1972) provided an exhaustive account of uses of plant growth regulators in several forms. Wittwer (1978) analysed the major practical uses of plant growth regulators in crops production. The research work done during last few years on growth, yield and physico-chemical characteristics of fruits as affected by different plant growth regulators is reviewed below. Since literature available on this aspect with guava is limited, therefore, work done on other fruit crops has also been included to support the present investigation.

2.1. Effect of plant growth regulators on vegetative growth

2.1.1 Effect of NAA :

Mohammed *et al.* (1984) reported that application of NAA, especially at higher concentration in guava reduced the height of the plants under UHDP system. However, the influence of plant growth regulators and their interaction with UHDP on number of branches / plants and length of longest branch / Plant were non-significant.

Ao and Sarma (1999) concluded that application of NAA at 50 ppm significantly increased the number of leaves and leaf area over control in pineapple. Similarly, Singh and Singh (1972) observed that foliar application of 20 and 40 ppm NAA on mango cv. 'Dashehari' significantly increased the length of terminal shoot and number of leaves they bore. Choi and Minsoon (2001) reported that application of NAA in "Fuji" apple significantly decreased shoot growth and regrowth rate. They further concluded that 2 or 3 application of NAA (60-70 days after full flowering) at the concentration of 10 to 40 mg / l can control the canopy size in high density orchard system.

2.1.2 Effect of ethrel :

Tao *et al.* (1998) found that application of 1000 ppm Ethephon to 'Fuji' apple reduced the shoot growth rate to a very great extent. Similar effect of reduction in vegetative growth due to application of Ethephon in guava under UHDP was also recorded by Mohammed *et al.* (1984). Banon *et al.* (2001) found that ethephon at different concentration inhibited plant growth, plant height, internodes length and also reduced leaf area significantly over control in oleander (*Nerium oleander*).

2.1.3 Effect of paclobutrazol :

Sarkar *et al.* (1998) summarized that paclobutrazol significantly suppressed the increase in tree height and canopy volume in mango. Although suppression of increase in the girth, spread and number of leaves were recorded and found statistically non significant. Similar trend of PBZ on vegetative growth was recorded by Kurian and Iyear (1993) in mango.

Application of paclobutrazol 10 g / tree in mango resulted reduced tree height (21.20%), tree volume (33.1%) and mean shoot length (48.2%). This response was attributed to GA – inhibitory activity of paclobutrazol (Murti *et al.*, 2001). Hussein *et al.* (1998) observed that application of paclobutrazol @ 150 ppm as foliar spray and 6 g / tree as soil drench reduced vegetative vigour like shoot length, shoot thickness, internode numbers etc. in order to improve tree productivity and fruit quality and also had significant positive effect on yield/tree in fig cv. ‘Sultania’

Application of paclobutrazol @ 1000 ppm in ‘Fuji’ apple reduced the shoot growth significantly over control, (Tao *et al.*, 1990). Similarly, Lichev *et al.* (2001) found that application of cultar (25% paclobutrazol) significantly inhibited the annual shoot growth and improves photosynthetic activity which may increase yield in cherry.

2.1.4 Effect of CCC :

Shikamany and Reddy (1989) observed that application of CCC (1000 ppm) in grape was effective in reducing shoot vigour and leaf area. Similar reduction of growth in grape cv. ‘Thompson Seedless’ by application of 1500 ppm CCC was reported by Albuquerque *et al.* (2000).

Ghora *et al.* (2000) observed that application of 500 ppm CCC in red raspberry reduced primocane height without reducing the number of nodes. Similarly, Sarkar *et al.* (1998) reported that application of CCC at 750 to 3000 ppm in mango reduced the tree height, spread, canopy area and no. of leaves significantly over control.

2.1.5 Effect of triacontanol :

In guava Mandal and Kumar (1989) found that foliar spray of triacontanol in the form of mixtalol @ 6 ml/10 l water was found to be effective with respect to length of terminal shoot, number of leaves and increase in leaf area. Further, plants sprayed three weeks before fruit set was better than those sprayed three weeks after fruit set and control.

Nagalaxmi and Gunasekaran (1989) reported that the total number of leaves and growth of ‘Poovan’ banana was maximum, when triacontanol was applied three times at the rate of 5 g /

plant in vermiculture medium. Similarly, Hangastor and Ries (1978) reported that triacontanol increase growth of *in vitro* cells culture of haploid tobacco.

Power *et al.* (2000) found that spray of 0.5 per cent triacontanol resulted in the highest value for vine length, number of leaves and 100 leaf weights in betelvine. Similar beneficial effect of triaontanol on vegetative growth of betelvine was also recorded by Arulmozhiyan (2000). Application of 3 ppm triacontanol in tea plant increased leaf area, leaf : shoot ratio and dry matter content (Barua and Das, 2000).

2.2. Effect of plant growth regulators on flowering and fruiting

2.2.1 Effect of NAA :

Agamy and Shaltout (1989) reported that application of NAA @ 50 ppm on 10 years old guava tree during three successive seasons at flowering and fruit setting stage and resulted better flowers and fruit set by NAA treatment over control. Hassan and Eissa (1996) reported that spray of 50 ppm NAA increased fruit set and decreased of June and pre harvest drop in guava fruits. Similar results were observed in apple by Marini *et al.* (1993) and in grape by Rao and Nalawadi (1968) which might be due to thickness of pedicel of the fruit.

Bal *et al.* (1984) found that foliar spray of 25 ppm NAA in 'Sanaur-5' variety of *ber* reduced fruit drop percentage significantly over control. Similarly, Bankar and Prasad (1993) found that NAA at 10, 20 and 30 ppm improved fruit set and retention in *ber* compared with control. The fruit weight and length were also significantly increased by the application of 30 ppm NAA. Pandey (1999) reported that application of 20 ppm NAA resulted in the greatest fruit retention and increased size, weight, volume and total yield of *ber* fruits.

Singh *et al.* (1994) reported that there was increased fruit retention and fruit size (length and diameter of fruit) with the increase in the concentration of NAA in mango. Sharma *et al.* (1990) observed that spray of 400 ppm NAA in mango cv. 'Langra' significantly increased per cent fruit set, fruit retention and reduced the fruit drop. Application of 20 ppm NAA in 'Alphonso' mango has increased number of flowers/panical (Vijaylakshmi and Srinivasan, 1998).

Baghel and Tiwari (2003) concluded that spray of 6 per cent urea and 150 ppm NAA in mango found superior for increasing the total number of flowers/panicle and percentage of hermaphrodite flowers. However, maximum flowering and fruiting and number of fruits/tree was recorded under combined application of 4 per cent urea and 150ppm NAA.

Application of 15 ppm NAA in 'Fuzi' apple has increased the fruit setting percentage over control (Tao *et al.*, 1998). Similarly, 16 ppm NAA in "Golden Spur" apple improved fruit

growth (Nieto *et al.*, 2000). Greenberg *et al.* (2000) sprayed NAA (300 ppm) in June on fruit-lets of mandarins and found decreased fruit numbers and increased fruit size without affecting total yield. Yeshayahu *et al.* (2001) stated that spray of 300 ppm NAA increased fruit size of 'Myovaze Satsuma' mandarin and NAA also thinned the fruit-lets and decreased total yield.

In an experiment of effect of ambient temperature and defoliation on flower bud induction with chemicals in pineapple, Onaha *et al.* (2001) reported that application of NAA induced flower bud induction. They further stated that the strong effect of NAA on flower bud induction required the presence of healthy green leaves.

Kumar and Sathiamoorthy (2002) found that spray of 150 ppm NAA in black pepper registered highest percentage of berry set. Similarly, Singh and Mukherjee (2000) found that foliar application of 75 ppm NAA with urea increased fruit set, fruit weight and decreased fruit drop percentage in chilli and time taken to 50 per cent flowering was also decreased.

2.2.2 Effect of ethrel :

Brahmachari *et al.* (1995) reported that application of ethrel at 25 or 50 ppm in guava enhanced fruit set percentage, weight, quality of fruit while, reduced number and weight of seeds thereby increased pulp / seed ratio. In a study on induction flowering in off year mango cv. "Alphonso" as influenced by chemicals and growth regulators, the foliar spray of ethrel @ 200 ppm has increased number of flowers / panical. (Vijayalakshmi and Srinivasan, 1998). Similarly, Ramburn (2001) reported that foliar application of 0.5 gm PBZ + 0.4 gm ethephon / l promoted flowering in litchi with erratic fruiting.

Turn bull *et al.* (1999) studied routes of ethephon uptake in pineapple and reasons for failure of flower induction and found that ethylene releasing agents such as ethephon are used widely to induce flowering in pineapple. Likewise, Onaha *et al.* (2001) found higher percentage of flower bud induction in pineapple by application of ethephon.

2.2.3 Effect of paclobutrazol :

Vijayalakshmi and Srinivasan (1998) reported that soil drenching of PBZ @ 10 ml/tree in mango increased number of flowers / panical. Lichev (1999) reported that soil drenching with PBZ 4 g / tree in mango resulted 5-6 days earlier flowering compared to control. Similarly, an experiment on effect of paclobutrazol application on growth of mango and detection of residues in leaves and soil was conducted by Subhadrabandhu *et al.* (1999) and they found that application of 1000 ppm PBZ had significantly increase both flowering and fruit set. Albuquerque *et al.* (2000) reported that application of PBZ increased the flower induction in mango. Singh (2000) concluded that application of cultar (25 % PBZ) promoted flowering, fruit

set and yield and reduced tree vigour in mango. Sao and Reboucas (2000) found that mango tree received, PBZ flowered, fruited and harvested earlier than those of control. Whereas, Murti *et al.* (2001) recorded that by application of PBZ 10 gm a.i. / tree in mango resulted in profuse flowering with marked reduction in the dormant shoot.

Application of 1000 ppm PBZ in apple induced flower bud formation and increased leaf chlorophyll content. (Tao *et al.*, 1998) Jindal and Chandel (1996) observed that spray of 300 ppm PBZ significantly increase fruit set in plum can be achieved by spray of 300 ppm paclozutrazol over control. Similar increase in fruit set with application of PP 333 in plum was recorded by Webster and Quinlan (1984) and in apple by Stinchombe *et al.* (1984). While, Singh (2000) concluded that application of 200 ppm PBZ in *ber* was effective in minimizing fruit drop and fruit cracking.

2.2.4 Effect of CCC :

Brahmachari *et al.* (1995) studied effect of foliar spray (one before flowering and one a month after fruit set) of NAA, PCPA, 2,4,5-T, GA₃, Kinetin and CCC in 6 years old guava cv. Sardar and observed that spray of 250 and 500 ppm CCC has enhanced fruit set as well as improved weight and quality of fruit. Similarly, spray of 500 ppm CCC in guava cv. 'Sardar' before flowering induced the earliest flowering and highest numbers of flowers, fruit set and retention of fruits (Brahmachari *et al.*, 1996).

Foliar spray of 1500 ppm cycocel in grapes increased berry set up to 55 per cent was recorded by Sherawat *et al.* (1998). The foliar application of 100 and 200 ppm cycocel in grape increased per cent bud burst and advanced the peak on set of bud burst to an earlier date than control (water sprayed) and GA₃ treated plants (Marizouk *et al.*, 1998). Albuquerque *et al.* (2000) found that application of 1500 ppm CCC increased the number of fruiting buds in grape.

In red raspberries cv. 'Autumn Bliss' Ghora *et al.* (2000) conducted an experiment on effect of growth retardants (CCC, daminozide and paclobutrazol) on growth and development under plastic green house condition and found that application of 500 ppm CCC enhanced anthesis and fruit ripening by about 10 days.

2.2.5 Effect of triacontanol :

Mandal and Kumar (1989) found that by the foliar spray of triacontanol in the form of Miraculan @ 7.5 ml / 10 l water was found to be significantly better than control with respect to duration of flowering, per cent fruit set, time taken to maturity, minimum fruit drop percentage and maximum fruit retention percentage in guava cv. 'Sardar'. The spray made three weeks before fruit set was better than sprayed three weeks after fruit set. Singh and Reddy (1991) studied the effect on photosynthesis improving chemical in guava and reported that length and diameter of

fruit was not affected by these chemicals. Similarly, Burondkar and Gunjate (1991) conducted an experiment on effect of photosynthesis improving chemical on growth, yield and quality of mango and obtained non-significant effect of photosynthesis improving chemicals on length and breadth of fruit.

Barwa (1998) observed that foliar spray of 2.5 to 10 ppm triacontanol in 'Santa Rosa' plum increased fruit retention. Jindal and Chandel (1996) reported that application of 20 ppm triacontanol in plum significantly increased fruit set percentage over control and other treatments.

Zhang *et al.* (1988) reported that application of 1.0 to 2.0 ppm triacontanol in litchi cv. 'Lantek' resulted in increased fruit set when sprayed at flowering stage as compared to control. The result of the trial conducted with 10 years old cashew nut cv. 'No. 1' revealed that the maximum fruit retention (25.80%) was under triacontanol at 500 ppm while it was minimum (7.28%) under control (Konhar and Arunmech, 1988).

Sud and Parmar (1990) found that application of triacontanol at 300 ppm on apricot cv. 'New Castle' both on pea and pit hardening stage resulted in largest size fruit with highest sugar content.

2.3. Effect of plant growth regulators on yield

2.3.1 Effect of NAA :

Brahmachari *et al.* (1996) reported that spray of guava tree with 50 ppm NAA has resulted in enhancement of flowering, fruit setting and thereby total yield. Choudhary *et al.* (1997) reported that application 250 ppm NAA resulted highest yield in guava cv. L-49. Hassan and Eissa, (1996) found that spray of 50 ppm NAA and 50 ppm nicotianic acid in guava reduced fruit drop and significantly increased yield over control and other treatments. Gaur (1996) sprayed guava trees with 600 ppm NAA reduce rainy season crop. He further observed that application of NAA was effective to increase yield (93.33 kg / tree) as compared to control (37.96 kg / tree) in winter season. It also improved the fruit quality, size, TSS content of fruits and net income / tree (Rs. 209 / tree) compared with control (Rs. 153.38 / tree.). Yadav (1998) reported that best yield in guava with good fruit quality was observed by foliar application of 10 ppm NAA and with certain nutrients. He recorded the highest fruit yield (67.7 kg/tree), number of fruits (686 / tree), volume of fruit (107.5 CC), ascorbic acid content (192.1 mg / 100 gm pulp) and lowest unmarketable fruits (19.6 / tree) due to 10 ppm NAA treatment. Yield of guava fruits can be increased significantly over control by the application of NAA @ 20 to 60 ppm (Yadav *et al.*, 2001).

Singh *et al.* (1994) found that spray of NAA @ 10-20 ppm has increased the weight of fruit and thereby total yield significantly higher than control in mango. Baghel *et al.* (1989) observed that application of 6 per cent urea + 150 ppm NAA has increased yield significantly over control in mango. The effect of NAA and GA₃ spray on fruit retention, growth, yield and quality of *ber* cv. 'Banarasi' and 'Karak' was studied by Pandey (1999) and reported that by spray of NAA @ 5 to 20 ppm in *ber* has increased the weight of fruit, volume and total yield of fruits significantly over control.

Maibangra and Ahmed (2000) treated pineapple plant with 100 ppm NAA and found increased yield as compared to control. Similarly, spray of NAA in cashew nut had significantly improve the nut yield as compared to control (Ghosh, 1998). The application of 200 ppm NAA + 0.05 per cent copper sulphate has increased yield significantly over control in lime was reported by Singh and Rethy (1995).

2.3.2 Effect of ethrel :

Highest yield in 'Sardar' guava was recorded by spraying 1800 ppm ethephon (Singh *et al.*, 2000). However, Yadav *et al.* (2001) reported that by spray of 50 to 100 ppm ethrel to guava tree was significantly effective to lower down the yield than control and other treatments. This is due to ethrel reduced moisture content in fruit resulting in low fruit weight. Tao *et al.* (1998) reported that the spray of 1000 ppm ethephon in 'Fuji' apple improved yield and quality of fruit.

2.3.3 Effect of paclobutrazol :

Singh and Dhillon (1992) obtained significantly higher yield in mango by application of PP-333 treatment. Sarkar *et al.* (1998) found that application of cultar (25 % PBZ) in mango tree significantly increased the number of fruits / tree, weight of fruits and thereby total yield over control by 295 per cent. Patil and Talathi (1999) reported that PBZ application is highly remunerative and economically viable in mango cv. 'Alphonso'.

Anbu *et al.* (2001) observed that application of PBZ 5 ml / tree 90 days before bud break stage in mango gave highest number of fruit and total yield during both on and off year. Similar results were found by Yadav and Singh (1998) by application of 4 gm / tree PBZ. Similarly application of PBZ @ 200 ppm increased the fruit yield in *ber* and proved economic (Singh, 2000). Tao *et al.* (1998) reported that spray of 1000 ppm PBZ in 'Fuji' apple increased yield with better fruit quality. Lin *et al.* (2000) reported that spray of PBZ on 5-8 years old tree of plum increased the yield and fruit size. In raspberry Ghora *et al.* (2000) reported that application of PBZ @ 500 to 1000 ppm had increase yield by 66 per cent and higher concentration caused excessive dwarfness in plant.

2.3.4 Effect of CCC :

In an experiment on effect of growth substances on flowering and fruiting characters of 'Sardar' guava, Brahmachari *et al.* (1996) reported that all the growth substances increased flowering, fruit yield and quality compared with no treatment. However, CCC at 500 ppm induced the earliest flowering and highest number of flowers, fruit set, retention and yield.

Application of 3000 ppm CCC at 15 leaf stage in grape was found to be highly effective in increasing the yield / vine. Yield increased on account of growth retardant was mediated through increased number of cluster / vine (Shikhamany and Reddy, 1989). Cycocel spray at 1500 ppm increased bunch size and yield in grape (Sherawat *et al.*, 1998). Similarly in mango Sarkar *et al.* (1998) found that application of CCC at 750 to 3000 ppm increased the yield significantly over control in mango by improving the number of fruits / tree and weight of fruit.

Nath and Baruah (1999) conducted an experiment on regulation of flowering time, plant growth and yield in 'Assam' lemon with the help of pruning and growth regulators. They reported that spray of 3000 ppm CCC in lemon gave the highest yield. Which resulted the maximum net returns and benefit cost ratio. Ghora *et al.* (2000) found that application of 500 ppm CCC in red raspberry increased yield significantly by 90 per cent without affecting berry size compared to control or 100 ppm cycocel treatment.

2.3.5 Effect of triacontanol :

In guava Mandal and Kumar (1989) reported that triacontanol (Mixtalol 6 ml/10 l water) exhibited significantly higher yield than control. Further those trees treated three weeks before fruit set was found better than sprayed three weeks after to fruit set. Similar beneficial effect of triacontanol in tamarind was observed by Ilango and Vijaylakshmi (2002). They reported that application of triacontanol 20 ml / tree resulted maximum pod yield / tree over control.

Borowski *et al.* (2000) concluded that spray of triacontanol had significantly increased the chlorophyll content of leaves and yield of fruits in tomato than control. Murlidharan *et al.* (2000) found that spray of 0.1 per cent Vipul (triacontanol) at 300 ml / ha gave the significantly higher yield over control in tomato.

2.4 Effect of plant growth regulators on quality

2.4.1 Effect of NAA :

Purohit *et al.* (1977) found that the application of 40 or 80 ppm NAA on guava plant significantly improved fruit quality. Similarly, Brahmachari *et al.* (1995) reported that by application of NAA at 25 to 50 ppm in guava has enhanced fruit set, weight and quality of fruit.

NAA application further reduced the number and weight of seeds and increased pulp : stone ratio. Application of 50 ppm NAA was most effective in increasing TSS, Ascorbic acid content and sugar contents but reduced fruit acidity in terms of citric acid. Brahmachari *et al.* (1996) found that application of NAA at 25 to 50 ppm in guava cv. 'Sardar' improved fruit quality and produced lowest seeds / fruit over control. Yadav *et al.* (2001) concluded that fruit weight, organoleptic rating, TSS, ascorbic acid and total sugar content of guava fruits increased significantly over control by the application of NAA @ 20 to 60 ppm and decreased fruit pressure (kg / cm²) significantly to make it more acceptable.

Baghel *et al.* (1989) recorded that combined application of 6 per cent urea + 150 ppm NAA was best treatment for increasing the pulp percentage, TSS, reducing sugar and decreased acidity percentage in mango cv. 'Sunderja'. Singh *et al.* (1994) reported that there was significant increase in TSS, ascorbic acid, reducing, non-reducing and total sugar while acidity was decreased significantly by NAA application in mango. Similarly, application of 20 ppm NAA in mango cv. 'Alphonso' was effective in improving quality parameters with respect to increase in ascorbic acid, carotene content, TSS, total sugar, reducing sugar and sugar / acid ratio (Vijaylakshmi and Srinivasan, 2000).

Bal *et al.* (1984) observed that fruit weight, length, diameter and TSS of fruit has increased significantly by application of 25 ppm NAA in *ber* over control. This treatment has also increased TSS/acid ratio, Vit.-C content and reduced acidity of fruit. Similar results were observed by Bal *et al.* (1988) in *ber*. Singh *et al.* (1989) stated that the spray of 50 ppm NAA with some micronutrients gave the best result with regards to total sugar, TSS, acidity, TSS/acid ratio and ascorbic acid content in *ber* cv. 'Pewandi'. Application of NAA at 20 ppm has increased pulp / stone ratio, TSS, TSS / acid ratio and ascorbic acid content of *ber* fruits significantly over control (Pandey 1999).

In lemon, application of NAA (10 to 40 ppm) had significantly increased size, weight and juice content of fruits. The TSS, acidity and ascorbic acid content were also higher in the fruits treated with growth regulators than in the control (Josan *et al.*, 1998). Spray of 350 ppm NAA in 'Nagpur' mandarin Sawale *et al.* (2001) found significant superior quality of fruits with respect to TSS, acidity and ascorbic acid content of juice. Yeshayahu *et al.* (2001) found that application of 300 ppm NAA significantly increased fruit size of 'Satsuma' mandarin. Similar results were recorded by Greenberg *et al.* (2000) in 'Or-1' mandarin by the use of 300 ppm NAA sprayed in the month of June on fruit lets.

2.4.2 Effect of ethrel :

Singh *et al.* (1979) have reported that application of ethrel enhances the ripening in guava. Similar result was observed by Pandey *et al.* (1989) in guava. Yadav *et al.* (2001) concluded that by the spray of ethrel @ 50 to 100 ppm in guava was found to be significantly higher in organoleptic rating, TSS content, ascorbic acid and total sugar content of fruit and reduced fruit pressure over control. It may be due to softening of fruit with ethrel by action of cell wall hydrolysis and changes of complex substance to simpler ones as carried out in process of ripening which is under the control of ethylene.

Singh *et al.* (2002) found that spray of 300 ppm ethrel in apple orchard significantly increased in colour, TSS, total sugar, reducing sugar content and reduced titrable acidity of fruit over control. Similarly, spray of ethephon @ 300 ppm advanced ripening by 8 days and increased TSS content and colour development in apple (Nieto *et al.*, 2000). While, Singh *et al.* (2000) found that spray of “Kinnow” mandarin plants with 400 ppm ethephon resulted minimum fruit drop and maximum fruit size thereby higher marketable yield.

Vijaylakshmi and Srinivasan (2000) observed that application of ethrel 200 ppm in mango cv. “Alphonso” improved the chemical characters with respect to Vit-C, carotene, TSS, total sugar, reducing sugar and sugar acid/ratio of fruit while, acidity was reduced significantly over control.

Sandhu *et al.* (1989) sprayed ethephon on *ber* at two times (Feb and March) and found that 400 ppm ethephon increased total sugar, reducing sugar and ascorbic acid content of fruits over control and the ripening was advanced by 4 to 5 days and duration of harvesting period was shortened by 16 days by this treatment over control.

Farmahan and Dhiman (1998) treated the apricot tree with 300 ppm ethephon and found the largest size fruit with highest pulp : stone ratio, TSS, Vit-C and carotene content of fruit while, lower down the acidity compared with control.

2.4.3 Effect of paclobutrazol :

Yadav and Singh (1998) found that application of PBZ 4 g / tree has increased the quality of fruit in mango with respect to fruit firmness TSS, pH and yellowness index after harvest. Similarly, Vijaylakshmi and Srinivasan (2000) found that application of PBZ 10 ml / tree in mango cv. ‘Alphonso’ has improved the quality parameters such as ascorbic acid content, carotene, TSS, total sugar, reducing sugar and sugar acid ratio and reduced the acidity significantly over control.

Application of PBZ at 500 and 1000 ppm induced earliness of 12 days in red raspberry (Ghora *et al.*, 2000). In *ber*, Singh (2000) found that application of PBZ @ 150 ppm was effective in improving fruit quality in terms of fruit weight, TSS, pulp : stone ratio and storage life of fruits.

Jindal and Chandel (1996) observed that application of PBZ (PP-333) at 125 ppm in plum significantly increased the average fruit growth over control. Further, higher concentration (500 ppm) increased the fruit size (in terms of length and diameter), weight and volume over other treatments. They also observed significant increase in fruit firmness and pulp / stone ratio by application of 500 ppm PBZ when compared with control. The application of PBZ had significantly increased total, reducing and non-reducing sugar content of 'Santa-Rosa' plum fruit and acidity was reduced. Similar findings were observed by Erez (1984) in peaches, who observed increase in size of fruit with the application of PP-333.

2.4.4 Effect of CCC :

Brahmachari *et al.* (1996) found that application of CCC at 500 ppm in guava cv. 'Sardar' raised the TSS and TSS / acid ratio and lowered the acidity of fruits.

Sherawat *et al.* (1998) sprayed 500 to 1500 ppm cycocel at bloom in grape and found best fruit quality in terms of TSS and acidity. Ilango and Vijaylakshmi (2002) reported that application of 1500 ppm CCC in tamarind has significantly increased the pod weight, pod width, pod length, pulp weight, tartaric acid content, ascorbic acid, TSS per cent, protein, carbohydrate, reducing, non-reducing and total sugar content of tamarind pod over control.

2.4.5 Effect of triacontanol :

The acidity, TSS and ascorbic acid contents of guava fruit were not affected by triacontanol (Singh and Reddy, 1991). Jindal and Chandel (1996) reported that by application of 20 ppm triacontanol in plum had significantly increased total, reducing and non-reducing sugar contents of fruit over control. Barua (1998) summarized that foliar spray of triacontanol at 2.5 to 10 ppm in "Santa-Rosa" plum increased the weight and volume of fruits. Mahajan and Sharma (1999) observed that spray of triacontanol at 10 and 20 ppm in plum significantly increased fruit size, weight and TSS content of fruit over control. Ilango and Vijaylakshmi (2002) reported that application of triacontanol 20 ml / tree in tamarind has resulted significant increase in ascorbic acid content, total sugar and TSS content of pod over control.

Planting System

Shant *et al.* (1996) found that spacing dose not significantly affected fruit set, flower and fruit drop in guava. However, trees at 2×2 m had a lower yield / tree than those at 8×8 m but 10 fold higher yield / ha. Pruning significantly influenced cropping pattern, as pruning intensity increase, rainy season yield decreased. There was no fruiting with full shoot pruning in the rainy season.

Pandey *et al.* (1997) found that plant canopy height was highest in single hedge row system and lowest in cluster system and double hedge row system. Fruit yield / plant and average fruit weight decreased with increasing plant density but fruit yield / ha, total yield and net profit all increased with increasing plant density in guava orchard.

3. MATERIAL AND METHODS

An investigation entitled “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting” was carried out at instructional farm, Department of Horticulture, Rajasthan Collage of Agriculture, Udaipur during the year 2002-03 and 2003-04.

For this purpose following two set of experiments were conducted separately.

- (1) Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density planting system.
- (2) Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under traditional system of planting.

The material used and methodology followed during the experiment are described below :

3.1 Climatic condition

The experiments were conducted at instructional farm, Department of Horticulture, Rajasthan Collage of Agriculture, Udaipur (Rajasthan). Udaipur comes under the sub-tropical, semi-humid regions of India. It is situated at 24°-34’ Northern latitude and 73° - 42’ Eastern longitude at an elevation of 582.17 meters above mean sea level. The average annual rainfall of this tract ranges from 650-750 mm of which 90 per cent is received from the South-West monsoon during the period of late June to September and some times scanty showers occurs during winter months.

The details of weekly meteorological data related to temperature, relative humidity, sun shine hours and rainfall during the period of experiments for both the year i.e. 2002-03 and 2003-04 are presented in Table 3.1 and 3.2, respectively.

3.2 Plant material

Ten years old guava cv. ‘Sardar’ plants of uniform size and growth were selected at instructional farm, Department of Horticulture, Rajasthan Collage of Agriculture, Udaipur. For the first experiments 33 plants were selected from the high density planting blocks (3×3 m spacing) which were moderately pruned.

Like wise for the second experiment 33 guava plants were selected from the traditional system of planting block (6×6 m spacing). In this way total 66 plants were used for two set of separate experiments during two successive year i.e. 2002-2003 and 2003-2004.

3.3 Experimental details

3.3.1 Experiment – I “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density planting system.”

This experiment was laid out in simple Randomized Block Design (RBD) with three replications. The treatments consisted of five different plant growth regulators namely NAA, ethrel, PBZ, CCC and triacontanol with two concentrations of each. The plain distilled water was sprayed on the plants for control. In this way total eleven treatments were used in this experiment.

The treatment details are given below :

S. No.	Treatments	Concentration	Notation
1.	Control	Distilled water	C
2.	Naphthalein acetic acid (NAA)	100 ppm	N ₁
3.	Naphthalein acetic acid (NAA)	200 ppm	N ₂
4.	Ethrel	250 ppm	E ₁
5.	Ethrel	500 ppm	E ₂
6.	Paclobutrazol (PBZ)	250 ppm	P ₁
7.	Paclobutrazol (PBZ)	500 ppm	P ₂
8.	Chloromequat (CCC)	500 ppm	C ₁
9.	Chloromequat (CCC)	1000 ppm	C ₂
10.	Triacontanol	5 ppm	T ₁
11.	Triacontanol	10 ppm	T ₂

Other details of experiment are :

- Total number of treatments – 11
- Number of replication – 03
- Number of plants in each treatments – 01
- Total numbers of plants used for experimentation – 33
- Age of plants – 10 years
- Plant spacing - 3×3 meters
- Date of treatment application – 16th July 2002 and 2003.

3.3.2 Experiment – II “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava L.*) cv. ‘Sardar’ under traditional system of planting.”

This was also laid out in simple Randomized Block Design (RBD) with three replications. The treatments consisted of five different plant growth regulators namely NAA, ethrel, PBZ, CCC and triacontanol with two concentration of each. The plain distilled water was sprayed on the plants for control. In this way total eleven treatments were used in this experiment.

The treatment details are as follows :

S. No.	Treatments	Concentration	Notation
1.	Control	Distilled water	C
2.	Naphthalein acetic acid (NAA)	100 ppm	N ₁
3.	Naphthalein acetic acid (NAA)	200 ppm	N ₂
4.	Ethrel	250 ppm	E ₁
5.	Ethrel	500 ppm	E ₂
6.	Paclobutrazol (PBZ)	250 ppm	P ₁
7.	Paclobutrazol (PBZ)	500 ppm	P ₂
8.	Chloromequat (CCC)	500 ppm	C ₁
9.	Chloromequat (CCC)	1000 ppm	C ₂
10.	Triacontanol	5 ppm	T ₁
11.	Triacontanol	10 ppm	T ₂

Other details of experiment are :

- Total number of treatments – 11
- Number of replications – 03
- Number of plants in each treatments – 01
- Total numbers of plants used for experimentation – 33
- Age of plants – 10 years
- Plant spacing - 6×6 meters

Date of treatment application – 16th July 2002 and 2003.

3.4 Techniques of treatments

(a) Plant growth regulator used :

The plant growth regulators i.e. NAA, CCC, Paclobutrazol, ethrel and triacontanol were selected and procured from different sources for the purpose of experiments. Cultar (25% PBZ)

was used as a source of paclobutrazol. Similarly, the booster (1000 ppm triacontanol) was used as a source of triacontanol which is manufactured and marketed by Ashar Chemicals Pvt. Ltd. Shapar Rajkot (Gujrat).

(b) Preparation of spray solution of the plant growth regulators :

Aqueous solutions of the plant growth regulators was prepared. For the preparation of 1000 ppm stock solution of NAA, 1 gram chemical was taken in a volumetric flask and dissolved in little quantity of alcohol then the volume was made up to one liter by adding distilled water. Similarly, to prepare 1000 ppm stock solution of CCC, 1 gram CCC was taken in a volumetric flask and dissolved in distilled water to make the volume up to one liter. Therefore, for the preparation of 100 and 200 ppm solution of NAA, 100 ml and 200 ml of stock solution was further diluted to make the volume of 1 liter, respectively. Similarly, for the preparation of 500 ppm CCC solution, volume of 500 ml stock solution was raised up to one liter through addition of distilled water. In this way required quantity and concentration of 100 and 200 ppm NAA and 500 ppm CCC solution were prepared.

For the preparation of 1000 ppm stock solution of paclobutrazol 4 ml cultar (25 per cent paclobutrazol) was taken in volumetric flask and volume was made up to one liter by adding distilled water. While for 1000 ppm stock solution of ethrel 1 ml chemical was taken in conical flask and volume was raised to 1 liter by adding distilled water. Similarly, for 10 ppm stock solution of triacontanol, 10 ml booster (0.1%) was taken in conical flask and volume was raised to 1 liter by addition of distilled water. From these stock solution to prepare 250 and 500 ppm paclobutrazol, 250 and 500 ppm ethrel and 5 ppm triacontanol solution the respective stock solutions were diluted with required quantity of distilled water separately.

(c) Application of plant growth regulators :

Ten years old guava trees of cv. 'Sardar' of uniform vigour and size were selected for investigation. Whole tree was used as single experimental unit. All the treatments were arranged in Randomized Block Design and each treatment was replicated thrice. Thus, total of 33 plants were selected for each set of experiment under high density and traditional system of planting. The selected trees were sprayed with different concentration of NAA, CCC, paclobutrazol, ethrel and triacontanol on 16th July for two successive year i.e. 2002 and 2003. Few drops of teepol was mixed in spray solution as a surfactant. Spraying was done by Maruti foot sprayer @ 1.5 liter/plant in high density planting system and 2.5 liter/plant in traditional system of planting. For control, plants were sprayed with distilled water.

3.5 Observations

The following observations were recorded during experimental period. In case of vegetative growth characters observations were recorded at 15 days interval after recording initial observations in each treatment for a total period of 75 days.

3.5.1 Vegetative growth characters :

- (i) Increase in shoot length (%)
- (ii) Increase in shoot diameter (%)
- (iii) Number of leaves per shoot

3.5.2 Flowering and fruiting characteristics :

- (i) Days taken to initiation of flowering
- (ii) Number of flowers per shoot
- (iii) Fruit set (%)
- (iv) Fruit retention (%)
- (v) Days taken to harvesting (Maturity days)

3.5.3 Physical characteristics of fruit :

- (i) Length of fruit (cm.)
- (ii) Diameter of fruit (cm)
- (iii) Weight of fruit (g)
- (iv) Volume of fruit (cc)
- (v) Specific gravity (g/cc)
- (vi) Organoleptic rating

3.5.4 Chemical characteristics of fruits :

- (i) T.S.S. (%)
- (ii) Acidity (%)
- (iii) Ascorbic acid (mg/100g pulp)
- (iv) T.S.S. / Acid ratio
- (v) Pectin content of fruit (%)

- (vi) Sugar content of fruit
 - (a) Reducing sugar (%)
 - (b) Non-reducing sugar (%)
 - (c) Total sugar (%)

3.5.5 Yield :

- (i) Yield (kg / plant)
- (ii) Estimated yield (tonnes / ha)

3.6 Methodology used for observations

3.6.1 Vegetative growth characteristics :

(a) Shoot length :

Five newly emerged uniform size shoots were randomly selected and tagged in each treatment. The initial length of tagged shoot was measured with the help of meter scale at the time of treatment application. Then periodical length of shoots was measured at 15 days interval for a total period of 75 days. The per cent increase in length of shoot was calculated on the basis of initial length of shoot on each day of observation.

(b) Shoot diameter :

For measuring the diameter of shoot, the five randomly selected shoots were marked at IInd internode in each treatment. The initial diameter of shoot was measured by digital vernier caliper at the time of treatment application. Then periodical observation of shoot diameter was taken at 15 days interval for a total period of 75 days. The per cent increase in diameter of shoot was calculated on the basis of initial value.

(c) Number of leaves / shoot :

The numbers of leaves were calculated on every labeled shoot at the time of measuring their length for a total period of 75 days.

3.6.2 Flowering and fruiting characteristics :

(a) Days taken to initiation of flowering :

Days taken to initiation of flowering were recorded by visual observation through regular visiting of the orchard during experimentation period.

(b) Number of flowers per shoot :

The total numbers of flowers were counted on the five randomly selected shoots and average number of flowers / shoot was calculated.

(c) Fruit set :

Total number of flowers which set into fruits are counted and per cent fruit set was calculated on the basis of number of flowers emerged.

(d) Fruit retention :

Total numbers of fruit set present on the tagged shoots were counted and then the total numbers of fruit were again counted at the time of fruit maturity. The per cent fruit retention was calculated on the basis of initial number of fruit set.

(e) Days taken to harvesting :

Number of days taken to harvesting was counted from the date of treatment to first picking in each treatment.

3.6.3 Physical Characteristics of Fruit :

(a) Length of fruit (cm) :

At the time of harvest ten fruits were selected randomly in each treatment and length of the fruit was recorded longitudinally with the help of digital vernier caliper in centimeters and average length of fruit was calculated.

(b) Diameter of fruit (cm) :

Diameter of the randomly selected ten fruits in each treatment was recorded transversely with the help of digital vernier caliper in centimeter and averaged.

(c) Weight of fruit (g) :

Randomly selected ten fruits in each treatment during harvesting were weighted with the help of single pan balance and mean weight of fruit was calculated.

(d) Volume of fruit (CC) :

The volume of ten randomly selected fruits in each treatment was measured by water displacement method. For this purpose, the fruits were dipped in a full filled jar of water and the water displaced by the fruits was collected and measured by graduated glass jar and the recorded reading was averaged.

(e) **Specific gravity (g/cc) :**

The specific gravity of the fruits was worked out by dividing the weight of fruit by volume of same fruits and expressed as g/cc.

(f) **Organoleptic rating :**

A panel of five judges conducted organoleptic test of the fruits immediately after harvesting in each treatment. The observation were recorded on the basis of flavor, colour, taste and general appearance of fruit and rated as below out of 10.0 score :

Excellent	:	9.1 to 10.0
Very Good	:	8.1 to 9.00
Good	:	6.1 to 8.0
Acceptable	:	5.1 to 6.0
Non-acceptable	:	0 to 5.0

3.6.4 Chemical characteristics of fruit :

(a) **Total soluble solids (TSS %) :**

Total soluble solids of the fruit was determined by using a hand refractometer of 0-30 per cent range. In this case one drop of fruit juice was put on the prism of the refractometer and per cent TSS was recorded directly. The values were corrected at 20°C and expressed as per cent total soluble solids of the fruits (A.O.A.C. 1990).

(b) **Acidity :**

The acidity was determined by diluting the known volume of clean juice with distilled water and titrating the same against standard $N/10$ NaOH solution using phenolphthalein as an indicator until faint pink colour was appeared. The result was expressed in terms of per cent acidity of the fruit juice (A.O.A.C. 1990).

(c) **Ascorbic acid (vit.-c) mg / 100 g pulp :**

Ascorbic acid content of juice was determined by diluting the known volume of clean juice with 3 per cent metaphosphoric acid to appropriate volume. A 10 ml of aliquot was taken and titrated against 2, 6 dichlorophenol indophenol solution after standardization (A.O.A.C. 1990) until light pink colour appeared. The result was expressed as mg ascorbic acid / 100 g pulp.

Standardization

Standardization of the 2, 6 dichlorophenol-indophenol dye was done by titrating it against standard ascorbic acid solution. The standard solution was prepared by dissolving 100 mg of L-ascorbic acid in 3% metaphosphoric acid and the volume was made to 100 ml and from this one ml solution was used for titration.

The ascorbic acid was calculated by following formula :-

$$\text{Ascorbic acid (mg/100 g pulp)} = \frac{\text{Titre(ml)} \times \text{Dye factor} \times \text{Volume made up (ml)}}{\text{Aliquot (ml)} \times \text{Weight of pulp (g)}} \times 100$$

Where, Titre – Average burette reading

$$\text{Dye Factor} = \frac{0.5}{\text{Average burette reading for standardization of dye solution}} \times 100$$

Aliquot – Volume of aliquot taken for estimation.

(d) TSS / acid ratio :

TSS / Acid ratio was calculated by dividing the value of total soluble solid content by per cent acidity.

(e) Pectin content of fruit :-

Water soluble pectin was determined by 'calcium pectate' method (Ranganna, 1977). For this purpose ten gram of dried fruit powder was boiled with distilled water continuously for one hour. The extract was cooled and volume was made to 500 ml then filtered through whatman No. 41 filter paper. A 100 ml of filtrate was taken to which 100 ml of distilled water and 10 ml of 1N NaOH were added and kept over night. The 50 ml of 1N acetic acid was added with continues stirring. After allowing it to stand for 1-2 minutes the solution was filtered through oven dried whatman filter paper No. 41. The precipitates were washed with boiling distilled water till free from chloride. The filter paper containing the precipitates were dried and weighted. The results were expressed in per cent calcium pectate on dry weight basis.

Formula

$$\text{Pectin (\%)} = \frac{\text{Weight of calcium pectate} \times \text{Volume made with distilled water}}{\text{Volume of aliquot taken} \times \text{Weight of sample}} \times 100$$

(f) Sugars :

- (i) Reducing sugar :-** Reducing sugar content was measured by following Nelsons Modifications of Somogyis Method (Somogyi, 1952) using arsenomolybdate colour forming reagent and two copper reagent 'A' and 'B' (Appendix XXIII). One ml of juice (100 times diluted) was added with a mixture of 1 ml copper reagent, from 24 parts of copper 'A' and 1 part of copper 'B' solution. This mixture was heated in boiling water bath in test tube and cooled, added with the colour forming reagent and absorbance was measured at 620 nm on Spectronic-20. The value was plotted against a standard curve prepared from glucose. The figures were expressed on percentage basis.
- (ii) Non-reducing sugar :-** The amount of non-reducing sugar was obtained by subtracting reducing sugar from the amount of total sugar and multiplying the resultant by factor 0.95.

$$\text{Non-reducing Sugar \%} = (\text{Total Sugar \%} - \text{Reducing Sugar \%}) \times 0.95$$

- (iii) Total sugar :-** Total sugar content was determined by using anthrone reagent method (Dubois *et al.*, 1951). To 1 ml of diluted fruit juice (100 time), 5 ml of anthrone reagent was added, then heated for 10 to 15 minute in a water bath, cooled to room temperature and absorbance was measured at 630 nm on Spectronic-20. The amount of sugar present in juice was plotted against standard curve prepared from glucose. The content was expressed on percentage basis.

3.6.5 Fruit yield :

(a) Yield per plant (Kg) :

Mature fruits were harvested periodically in each treatment separately and the weight was recorded with the help of single pan balance. Then the total yield (Kg / plant) was calculated.

(b) Estimated yield per ha (Tonnes) :

The yield of fruits per ha was calculated by multiplying the yield of fruit per plant with number of plant per ha i.e. 1111 plants / ha in high density planting system (spacing 3×3 m) and 278 plants / ha in traditional system of planting (spacing 6×6 m).

3.6.6 Economics of the treatments used :

The relative economics of different plant growth regulator treatments were determined on the plant basis of cost of treatment and yield of fruit per plant and per ha. The net income was

decided by subtracting the treatment cost from gross income. It was expressed on net excess income over control. The percent increase in net profit over control was also calculated under both the system of planting, separately.

3.7 Statistical analysis

The data of two years (2002-03 and 2003-04) were pooled together and then obtained data on various characters were subjected to Randomized Block Design (RBD) analysis and interpretation of the data was carried out in accordance with Panse and Sukhatma (1985). The level of significance used in 'F' test and 't' test was $P = 0.05$ critical difference values were calculated where ever the 'F' test was significant. The values calculated in per cent were subjected to angular transformation according to the table given by Snedecor and Cochran (1967). The analysis of variance for different characters are presented in Appendices I to XXII.

Fig – 3.1 Layout plan of high density planting block at instructional farm, Department of Horticulture, R.C.A., Udaipur.

Open Well		E ₁ R ₁	N ₂ R ₁	N ₁ R ₁
		E ₂ R ₁	-	P ₁ R ₁
		-	C ₁ R ₁	P ₂ R ₁
		C ₂ R ₁	-	Control ₁
-	E ₁ R ₂	N ₂ R ₂	T ₁ R ₂	T ₂ R ₁
T ₂ R ₂	C ₂ R ₂	P ₁ R ₂	-	-
P ₂ R ₂	T ₁ R ₂	Control ₂	N ₁ R ₂	E ₂ R ₂
C ₁ R ₂	E ₂ R ₃	-	P ₂ R ₃	T ₂ R ₃
Control ₃	-	N ₁ R ₃	-	-
T ₁ R ₃	N ₂ R ₃	-	-	E ₁ R ₃
P ₁ R ₃	C ₂ R ₃	-	C ₁ R ₃	-

Fig – 3.2 Layout plan of traditional system of planting block at instructional farm, Department of Horticulture, R.C.A., Udaipur.

_____ **Road / Path** _____

-	Control ₁	N ₁ R ₂	N ₁ R ₃	E ₂ R ₃	P ₂ R ₃
N ₁ R ₁	T ₂ R ₁	Control ₂	P ₁ R ₃	-	-
N ₂ R ₁	T ₁ R ₁	T ₂ R ₂	T ₁ R ₃	C ₁ R ₃	C ₂ R ₃
E ₁ R ₁	C ₂ R ₁	C ₂ R ₂	E ₁ R ₃	T ₂ R ₃	Control ₃
E ₂ R ₁	C ₁ R ₁	N ₂ R ₂	P ₂ R ₂	E ₁ R ₃	P ₁ R ₂
P ₁ R ₁	P ₂ R ₁	T ₁ R ₂	E ₂ R ₂	N ₂ R ₃	C ₁ R ₂

Table 3.1 Weekly meteorological data for the year 2002-03.

Standard Week	Period From To	Temperature (°C)		R.H. % at		Sun shining hours	Total Rainfall (m.m.)
		Max.	Min.	AM 07:35	PM 14:35		
	Year 2002						
29.	16-22 July	32.0	24.9	72	56	5.7	0.0
30.	23-29 July	30.7	24.5	73	56	5.3	0.0
31.	30 July-5 Aug	32.6	23.7	83	61	5.1	62.4
32.	6-12 Aug	28.3	23.3	91	83	1.5	62.2
33.	13-19 Aug	28.1	23.1	83	71	1.6	2.6
34.	20-26 Aug	30.5	23.0	88	70	7.4	51.7
35.	27-2 nd Sept	28.8	22.3	86	69	5.3	27.2
36.	3-9 Sept	31.3	21.8	88	61	7.9	28.4
37.	10-16 Sept	31.8	20.1	74	44	10.6	0.00
38.	17-23 Sept	30.8	20.1	79	55	8.8	2.9
39.	24-30 Sept	33.5	20.5	72	44	9.1	12.8
40.	1 st – 7 th Oct	36.3	17.3	62	23	10.5	0.0
41.	8-14 Oct	36.4	19.0	71	32	9.8	3.0
42.	15-21 Oct	34.5	17.0	64	21	9.6	0.0
43.	22-28 Oct	33.3	14.4	55	16	10.0	0.0
44.	29 th -04 th Nov	33.2	13.5	61	15	9.8	0.0
45.	5-11 Nov	31.0	13.6	71	25	9.3	0.0
46.	12-18 Nov	28.7	12.0	71	27	9.1	0.0
47.	19-25 Nov	30.6	11.6	70	23	8.6	0.0
48.	26 th -2 nd Dec	28.6	9.6	69	21	9.2	0.0
49.	3-9 Dec	28.4	9.3	66	27	9.4	0.0
50.	10-16 Dec	30.4	9.5	71	21	9.5	0.0
51.	17-23 Dec	29.7	11.0	78	27	9.6	0.0
52.	24-31 Dec	25.0	8.9	80	37	8.4	1.8
	Year 2003						
01.	1-7 th Jan	21.7	6.6	90	39	9.4	0.0
02.	8-14 Jan	24.0	6.3	71	29	9.6	0.0
03.	15-21 Jan	26.4	4.9	69	22	10.1	0.0
04.	22-28 Jan	29.1	9.5	77	25	8.9	0.0
05.	29 th -04 th Feb	24.5	9.6	84	41	8.9	2.1
06.	5-12 Feb	26.8	8.9	75	31	9.6	0.0
07.	12-18 Feb	26.6	9.8	62	31	8.4	10.4
08.	19-25 Feb	26.9	10.9	74	29	9.3	0.0
09.	26-04 March	30.6	14.1	60	23	10.4	0.0

Source – Agromet Observatory, RCA Udaipur.

Table 3.2 Weekly meteorological data for the year 2003-04.

Standard Week	Period From To	Temperature (°C)		R.H. % at		Sun shining hours	Total Rainfall (m.m.)
		Max.	Min.	AM 07:35	PM 14:35		
Year 2003							
29.	16-22 July	31.8	24.7	90	68	6.4	16.3
30.	23-29 July	28.9	23.4	97	88	3.1	164.9
31.	30 July-5 Aug	28.2	22.7	93	80	4.2	11.2
32.	6-12 Aug	30.4	23.6	93	79	4.6	12.6
33.	13-19 Aug	31.1	24.2	85	67	6.5	0.0
34.	20-26 Aug	30.8	23.8	88	79	3.9	85.9
35.	27-2 nd Sept	28.4	22.9	90	78	2.3	20.1
36.	3-9 Sept	30.4	22.3	83	60	8.4	0.2
37.	10-16 Sept	30.8	21.6	83	64	8.7	2.4
38.	17-23 Sept	31.5	22.6	92	84	4.4	56.8
39.	24-30 Sept	31.7	21.0	89	61	7.9	6.6
40.	1 st – 7 th Oct	32.8	16.9	81	51	10.5	6.2
41.	8-14 Oct	33.3	16.6	74	33	10.6	0.0
42.	15-21 Oct	33.0	14.4	82	22	10.1	0.0
43.	22-28 Oct	32.6	12.7	67	18	10.2	0.0
44.	29 th -04 th Nov	31.8	14.6	69	27	10.0	0.0
45.	5-11 Nov	32.2	13.9	70	31	9.5	0.0
46.	12-18 Nov	30.4	12.5	76	29	9.6	0.0
47.	19-25 Nov	29.1	12.7	72	32	9.0	0.0
48.	26 th -2 nd Dec	28.9	10.4	78	31	9.3	0.0
49.	3-9 Dec	30.8	10.3	84	25	9.6	0.0
50.	10-16 Dec	28.1	10.8	83	33	8.7	0.0
51.	17-23 Dec	23.8	6.4	82	34	8.9	0.0
52.	24-31 Dec	23.0	5.9	91	42	8.6	0.0
Year 2004							
01.	1-7 th Jan	23.1	7.3	86	35	7.9	0.0
02.	8-14 Jan	26.2	7.0	84	27	9.5	0.0
03.	15-21 Jan	27.8	8.5	85	30	8.4	0.0
04.	22-28 Jan	23.0	6.5	89	36	8.5	0.0
05.	29 th –04 th Feb	23.3	5.8	86	26	8.9	0.0
06.	5-11 Feb	26.7	5.8	65	17	10.2	0.0
07.	12-18 Feb	29.3	9.1	77	27	10.1	0.0
08.	19-25 Feb	31.3	10.9	74	19	10.2	0.0
09.	26-04 March	32.5	11.0	73	19	10.5	0.0

Source – Agromet Observatory, RCA Udaipur.

5. DISCUSSION

An investigation entitled “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting” was carried out at instructional farm, Department of Horticulture, Rajasthan Collage of Agriculture, Udaipur during the year 2002-03 and 2003-04. For this purpose following two sets of experiments were conducted separately.

- (1) Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density planting system.
- (2) Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under traditional system of planting.

The observations were recorded on different aspects viz. vegetative growth characteristics (shoot length, shoot diameter and number of leaves), flowering and fruiting characters (days taken to initiation of flowering, number of flowers per shoot, fruit set, fruit retention and days taken to harvesting), physico-chemical characteristics of fruit (fruit length, fruit diameter, fruit weight, fruit volume, specific gravity, organoleptic rating, T.S.S., acidity, T.S.S / acid ratio, ascorbic acid content, pectin content, reducing, non-reducing and total sugar content of fruit) and yield (kg / plant and tones / ha). The results obtained are discussed below :

5.1 Vegetative growth characteristics

It is evident from the results obtained, that the application of plant growth regulator treatments at different concentration had significantly influenced various vegetative growth characters in both the year of experimentation (i.e. 2002-03 and 2003-04) under high density as well as in traditional system of planting as compared to control. In the present investigation it was observed that among the various plant growth regulator treatments attempted, application of NAA and triacantanol resulted the higher rate of increased shoot length as compared to other treatments. On 75 days after treatment application, the mean maximum increase in shoot length of 46.25 per cent under high density and 36.96 per cent under traditional system of planting were recorded due to 100 ppm NAA treatment which was closely followed by 200 ppm NAA (Table 4.1 and 4.12). Similar effect of increase in shoot length as a result of NAA treatment was also recorded by Singh and Singh (1972) in mango, who observed that 20 or 40 ppm NAA increased the length of terminal shoot.

The possible explanation of increased shoot length due to NAA treatment might be because of NAA enhances the growth of shoot by cell enlargement and cell elongation

mechanism through increasing amylase activity, permeability, formation of energy rich phosphate (ATP) and cell wall plasticity while, decreases viscosity and wall pressure (Pandey and Sinha, 2001). It is further evident from the present study that application of CCC, etrel and PBZ had significantly reduced the rate of increase in shoot growth over control. On 75 days after treatment in high density planting system, the mean minimum increase in shoot length of 33.10 per cent was recorded at 1000 ppm CCC treatment followed by 500 ppm PBZ (33.14 per cent). Whereas in traditional system of planting, the mean minimum increased in shoot length of 27.49 per cent was recorded at 500 ppm PBZ followed by 1000 ppm CCC (28.40 per cent) treatment (Table 4.1 and 4.12).

This response of paclobutrazol is attributed to GA-inhibitory activity of paclobutrazol, as gibberellins are, known to promote elongation growth (Tomar, 1984). Similarly in mango, Murti *et al.* (2001) observed that there was reduction in xylem radial width and increase in phloem in the shoots resulted higher ratio of radial width of phloem to xylem tissues is associated with dwarfing nature of trees, further land supports to our results. The reduction in rate of increase in shoot length as a result of CCC treatment might be due to reduction in the internodal length was also reported by Shikamany and Reddy (1989) in grape.

The present findings are in accordance to the findings of Sarkar *et al.* (1998) and Kurian and Iyer (1993) in mango, Hussein *et al.* (1998) in fig and Tao *et al.* (1998) in apple.

The data recorded on diameter of shoot as affected by various plant growth regulator treatments indicates that the application of plant growth regulator treatments increased the diameter of growing shoot significantly over control during entire period of growth up to 75 days after treatment in both high density and traditional system of planting. However, on 75 days after observation the mean highest increase in diameter of shoot (39.15%) was recorded in 1000 ppm CCC treatment which was closely followed by 200 ppm NAA (38.98%) and 500 ppm PBZ (38.94%) treatments in high density planting system. Similarly, in traditional system of planting the mean maximum increase in shoot diameter was observed (36.55%) in 500 ppm PBZ treatment and closely followed by 1000 ppm CCC (35.94%). Whereas, the mean minimum shoot diameter was observed in control in both the system of planting (Table 4.2 and 4.13). The highest increased in shoot diameter as a result of CCC and PBZ treatments might be due to reduction in apical growth and internodal length of the growing shoot as evident from the present study.

Similar results of increase in shoot diameter due to application of CCC was observed by Singh (1999), who found that application of 1500 and 3000 ppm CCC significantly increased the shoot diameter over control after 75 days of treatment in grape. He further stated that the overall increase in horizontal growth of vine as compared to vertical growth of the vine might be responsible for increase in shoot diameter.

In support of present findings Lichev *et al.* (2001) in cherry, reported that PBZ significantly inhibited the annual shoot growth and improved the photosynthetic activity, which may increase diameter of shoot. These findings are in line with the findings of Tao *et al.* (1998) in apple, Shikhamany and Reddy (1989) in grape and Sarkar *et al.* (1998) in mango.

The data on number of leaves / growing shoot as influenced by different plant growth regulator treatments in the present investigation are presented in Table 4.3 and 4.14 reveals that the application of these treatments significantly increased the number of leaves per growing shoot over control on all the days of observation from 15 to 75 days of treatments in both the systems of planting (high density and traditional system). However, on 75th day of treatment the mean maximum increase in number of leaves 7.06 (from 6.52 to 13.58) was recorded in 200 ppm NAA treatment followed by 100 ppm NAA i.e. 6.82 (from 6.40 to 13.22) in high density planting system. Whereas, in traditional system of planting the mean maximum increase in number of leaves of 6.91 (from 6.04 to 12.95) was recorded in 10 ppm triacontanol and followed by 5 ppm triacontanol i.e. 6.81 (from 6.17 to 12.98) treatment. The mean minimum number of leaves of 5.96 (from 6.40 to 12.36) was observed in 1000 ppm CCC followed by 500 ppm PBZ i.e. 6.02 (from 6.13 to 12.15) treatments in high density planting system. Similarly in traditional system of planting the mean minimum increase in number of leaves 5.21 (from 5.99 to 11.20) was recorded in 500 ppm PBZ treatment on 75th days after treatment.

The results are in accordance to the findings of Asrey *et al.* (2003) who reported that application of NAA / triacontanol treatment are quite effective in increasing number of leaves / shoot in strawberry. The reduced rate of increase in number of leaves due to application of CCC and PBZ treatment in the present investigation is strongly supported by Sarkar *et al.* (1998) in mango. They further explained that this might be due to GA-inhibitory activity of CCC and PBZ. The increase in number of leaves due to application of NAA and triacontanol treatments might be due to increased photosynthetic activity in treated plants resulted in cell elongation and rapid cell division in growing portion (Sargent, 1965) Secondly it may be due to primary physiological effects of these growth regulators is to stimulate elongation and enlargement of cells due to increased enzymatic activity and permeability of cell wall (Salisbury and Ross, 1992).

The similar results in increase in number of leaves due to application of NAA / triacontanol were reported by Nagalakshmi and Gunasekaran (1989) in Banana, Mandal and Kumar (1989) in guava, Ao and Sarma (1999) in pineapple and Power *et al.* (2000) in betelvine.

5.2 Flowering and fruiting characteristics

Flowering and fruiting characteristics like days taken to initiation of flowering, number of flowers / shoot, percent fruit set, percent fruit retention and days taken to harvesting were

significantly affected by various plant growth regulator treatments at different concentrations as evident from the results presented in the preceding chapter. In the present investigation it was observed that all the plant growth regulator had significant beneficial effect on different flowering and fruiting characters under study over control in both high density and traditional system of planting. Further, among the various treatments attempted, the application of paclobutrazol and ethep (sic) exhibited better results on these characters than other treatments and control.

It is evident from the data (Table 4.4) that under high density planting system, the application of 1000 ppm CCC treatment resulted the minimum days taken to flowering (27.50 days) followed by 500 ppm PBZ (27.67 days). Similarly the highest number of flowers (7.63 / shoot) was recorded at 500 ppm ethep followed by 500 ppm PBZ treatment (7.50 / shoot). The minimum days taken to harvesting (115 days) was observed in 500 ppm ethep, which was closely followed by 500 ppm PBZ and 1000 ppm CCC treatments (117.50 days). Similarly under traditional system of planting, the minimum days taken to flowering (29.0) were recorded at 500 ppm ethep and 500 ppm PBZ treatment (Table 4.15). The highest number of flowers (7.77 / shoot) was recorded at 500 ppm PBZ treatment followed by 500 ppm ethep (7.73 / shoot). Likewise, the minimum days taken to harvesting (115.33 days) was recorded at 500 ppm PBZ treatment which was closely followed by 500 ppm ethep (115.50 days). Similar results of earliest and promoted flowering as well as earlier harvesting due to application of PBZ was recorded by Singh (2000) and Sao and Reboucas (2000) in mango, Jindel and Chandel (1996) in plum and Tao *et al.* (1998) in apple. Earlier and profuse flowering were also observed by application of ethep in mango (Vijayalakshmi and Srinivasan, 1998), Litchi (Ramburn, 2001) and in guava (Brahmachari *et al.*, 1996).

The application of plant growth regulator treatments had significantly increased the fruit set and fruit retention over control under both high density and traditional system of planting (Table 4.5 and 4.16). The mean maximum fruit set (71.78%) was recorded at 500 ppm PBZ treatment as compared to minimum (58.89%) in control. Similarly the maximum fruit retention (70.67%) was recorded at 500 ppm PBZ followed by 250 ppm PBZ (68.74%) treatment. The minimum fruit retention of 62.90 per cent was recorded at control in high density planting system. Likewise, in traditional system of planting the application of paclobutrazol also found significantly superior with regards to fruit set and fruit retention. Where, the mean maximum fruit set (71.17%) and fruit retention (73.16%) were recorded at 500 ppm PBZ treatment as compared to mean minimum at control i.e. fruit set of 57.50 per cent and fruit retention of 65.03 percent (Table 4.16). Similar beneficial effect of PBZ on fruit set and fruit retention was also recorded by Subhadrabandhu *et al.* (1999) and Albuquerque *et al.* (2000) in mango, Webster and Quinlan (1984) in plum and Stimchombe *et al.* (1984) in apple, which supports the present

results. The influence of PBZ to increase the percentage of flowering is attributed to GA-inhibitory activity of PBZ as gibberellins are known to promote elongation growth and inhibits flowering (Tomar, 1984). Further, the application of PBZ increased cytokinin, t-ZR and DHZR content, which are important translocational forms of growth promoting cytokinins. The increase in these ribosyl derived cytokinins is reported to act positively in flower bud formation (Murti *et al.*, 2001). Similarly, Agarwal *et al.* (1985) suggested that the increased cytokinins are associated with flower bud induction in mango.

5.3 Physical characteristics of fruit

It is evident from the results that application of plant growth regulators at different concentrations significantly improved physical characteristics of fruits like fruit size (length and diameter of fruit), fruit weight, fruit volume, organoleptic rating and specific gravity of fruit as compared to control. However in the present investigation the application of paclobutrazol and NAA at different concentration were found to be more superior to other treatments in both the system of planting i.e. high density and traditional system of planting.

The data recorded on length and diameter of fruit (Table 4.6) under high density planting system clearly indicate that application of PBZ at 500 ppm exhibited maximum fruit length (7.40 cm.) followed by 200 ppm NAA (7.12 cm.) treatment. However, the mean maximum diameter 7.30 cm. was recorded at 200 ppm NAA treatment, which was closely followed by 500 ppm PBZ (7.23 cm.). The mean minimum length (5.05 cm.) and diameter (5.94 cm.) was recorded at control.

The similar effects of PBZ and NAA were recorded in case of traditional system of planting. Where the mean maximum fruit length of 6.47 cm. was recorded at 500 ppm PBZ treatment (Table 4.17). The mean maximum diameter of fruit 6.74 cm. was also recorded in 500 ppm PBZ followed by 6.64 cm. in 200 ppm NAA treatment. The result obtained in present investigation is supported by the findings of Jindal and Chandel (1996) in plum. They observed that application of 500 ppm PBZ had significantly increased fruit size in terms of length, diameter, weight and volume of fruit. Erez (1984) also observed increase in size of peaches with the application of PP- 333 treatment. The increase in size of fruits due to application of NAA in the present investigation is supported by the finding of Brahmachari *et al.* (1995), who reported that the application of NAA at 25 to 50 ppm in guava had significantly increased the size of fruit over control.

Application of plant growth regulators had significantly increased the weight and volume of fruits over control (Table 4.7 and 4.18). However, in the present study, the mean maximum fruit weight (191.46 g) was recorded by 500 ppm PBZ treatment followed by 200 ppm NAA

(182.37g) as compared to mean minimum at control (139.42g). Similarly, the mean maximum volume of fruit (188.16cc.) was recorded at 500 ppm PBZ that was followed by 500 ppm NAA (178.95cc) while the mean minimum volume (129.31cc) was recorded in control under high density planting system. Whereas, in traditional system of planting the mean maximum weight and volume i.e. 179.32g and 172.45cc, respectively (Table 4.18) were recorded under 500 ppm PBZ treatment which was closely followed by 500 ppm NAA, as compared to mean minimum in control i.e. 132.46g and 118.56cc weight and volume of fruit, respectively. The increase in weight and volume of fruit due to PBZ treatment were also recorded by Singh (2000) in *ber* and Yadav and Singh (1998) in mango. The increase in size of fruit with respect to length, diameter, weight and volume of fruit due to application of PBZ might be because of the fact that partitioning of assimilates by PP-333 more towards the fruit development which is strong sink (Anbu *et al.* 2001).

The increase in size of fruit as a result of foliar application of NAA in present investigation might be due to application of NAA at different concentration had improved the internal physiology of developing fruit in terms of better supply of water, nutrients and other compounds vital for their proper growth and development which resulted in improved size and ultimately greater yield as compared to control (Pandey, 1999). The present results are corroborated the results of Greenberg *et al.* (2000) in mandarin.

The data presented in Table 4.7 and 4.18 revealed that specific gravity of fruit was significantly reduced by the different plant growth regulator treatment in both high density and traditional system of planting, over control. In high density planting experiment, the mean minimum specific gravity 1.018 was recorded at 500 ppm PBZ treatment followed by 500 ppm NAA (1.019). However the maximum specific gravity of 1.078 was observed at control. Similarly in traditional system of planting the mean maximum and minimum specific gravity of 1.038 and 1.118 were recorded at 250 ppm ethrel and control treatment, respectively (Table 4.18). The reduction of specific gravity of fruit due to plant growth regulator treatments might be because of increase in volume at higher rate of fruit as compared to weight of fruit under these treatments.

The organoleptic rating of guava fruit was significantly improved by application of different plant growth regulator treatments at various concentrations in both the system of planting (Table 4.6 and 4.17). It is evident from the data obtained that application of ethrel at 250 and 500 ppm concentration had exhibited highest organoleptic score as compared to other treatments and control in high density as well as in traditional system of planting. The mean maximum organoleptic score of 8.87 (in high density planting) and 8.67 (in traditional system of planting) were recorded at 500 ppm ethrel treatment. Where as the lowest organoleptic score of

6.75 and 6.25 were recorded at control in high density and traditional system of planting, respectively. The maximum organoleptic rating due to application of ethrel might be due to fact that the ethrel is a ripening hormone and increased the sugar acid ratio and reduced the fruit pressure, which is an index of fruit hardness or softness. The softening of fruit with ethrel might be explained through its action on cell wall hydrolysis and changes in complex substances to simpler ones as carried out in ripening which is under the control of ethylene (Yadav *et al.*, 2001). Similar organoleptic rating attributed characters like colour and taste was increased in apple by application of ethrel as it increased the activity of phenylalanine-ammonia lyase enzyme sharply in treated fruits, which seemed to be the determining factor of colour development (Singh *et al.*, 2002).

5.4 Chemical characteristics of fruit

It is evident from the results that the application of plant growth regulators in both high density and traditional system of planting had significantly improved the nutritional quality of fruits in terms of T.S.S., acidity, T.S.S./ acid ratio, ascorbic acid, pectin and sugars contents (reducing, non-reducing and total) of fruit as compared to control. It is further evident from the present results that among the various treatment of plant growth regulators in both the system of planting in guava, the application of ethrel, paclobutrazol and NAA at different concentration was found to be significantly superior over other treatments including control with respect to nutritional quality parameters of the fruit. However, in high density planting system the mean highest TSS (15.66%), lowest acidity (0.39%) and maximum TSS / acid ratio (40.40%) were recorded at 500 ppm ethrel treatment and 500 ppm PBZ was found second best treatment with regards to TSS, acidity and TSS / acid ratio (Table 4.8). Similarly, in traditional system of planting, the application of 500 ppm ethrel resulted the mean maximum TSS (15.35%), minimum acidity (0.375%) and mean maximum TSS / acid ratio (40.97%). Like high density planting experiment, the application of 500 ppm PBZ was found to be the second best treatment among all the treatments attempted in the present study (Table 4.19).

Similar beneficial effect on TSS, acidity and TSS / acid ratio was also recorded by Vijaylakshmi and Srinivasan (2000) in mango. The increase in TSS and reduction in acidity due to application of ethrel in the present investigation might be because of its action on converting complex substances (starch) into simpler ones (sugars) through higher respiration activity during ripening process (Yadav *et al.*, 2001). Singh *et al.* (2002) also reported increase in TSS and decrease in acidity by ethrel application in apple and stated that reduction in acidity might be due to utilization of acids during respiration. The increase in TSS and reduction in acidity due to application of paclobutrazol in the present investigation are supported by the finding of Vijaylakshmi and Srinivasan (2000) in mango. They explained that the beneficial effect of

paclobutrazol might be due to its influence on physiological process, particularly respiration and photosynthesis which possibly led to accumulation of dry matter, minerals and carbohydrates. The similar results of increase in TSS, reduction in acidity and there by increased TSS / acid ratio were also observed by application of these plant growth regulator treatments by Singh *et al.* (1979) in guava, Nieto *et al.* (2000) in apple and Sandhu *et al.* (1989) in ber.

The influence of plant growth regulator on ascorbic acid and pectin content of fruit under high density and traditional system of planting are presented in Table 4.9 and 4.20. The data reveals that the application of plant growth regulator had significantly increased the ascorbic acid and pectin content of the guava fruit over control. Among the various plant growth regulator treatments, the mean maximum ascorbic acid of 210.82 mg /100g pulp and pectin of 0.775 per cent were recorded at 500 ppm PBZ treatment which were closely followed by 200 ppm NAA under high density planting system (Table 4.9). However, in traditional system of planting the mean highest ascorbic acid 205.18 mg / 100 g pulp and pectin 0.80 per cent were recorded at 200 ppm NAA. Whereas, the minimum ascorbic acid (175.06 mg / 100 g pulp) and pectin content (0.61%) were observed at control. The present results are in line with the finding of Pandey (1999) in ber, Brahmachari *et al.* (1995) and Yadav *et al.* (2001) in guava, and Vijailakshmi and Srinivasan (2000) in mango.

The data presented in Table 4.10 and 4.21 clearly indicates that the application of plant growth regulators had significantly increased the sugar content (reducing, non-reducing and total sugar) of guava fruits in both the system of planting. In the present investigation under high density planting system, the highest reducing, non-reducing and total sugar content of 4.58, 3.11 and 7.86 per cent, respectively were recorded in 500 ppm ethrel treatment (Table 4.10). Whereas, the mean minimum reducing (3.93%), non-reducing (2.36%) and total sugar (6.43%) were recorded at control. Similarly, under traditional system of planting the highest reducing sugar (4.36%), non-reducing sugar (3.01%) and total sugar (7.53%) were observed at 500 ppm ethrel treatment. This treatment was followed by 500 ppm PBZ treatment under both the system of planting. Various workers have reported the improvement in the metabolic process of the plant, stimulation of enzymatic activity as a result of ethrel treatment. The plants treated with ethrel had higher quantity of soluble carbohydrate in the sap and glucose concentration was strikingly high due to marked increase in carbon assimilation (Yadav *et al.*,2001). The present results are corroborated with the finding of Singh *et al.* (2002) in apple, and Bhattacharya and Rao (1994) in papaya.

5.5 Yield

The effect of plant growth regulators on yield of guava under high density and traditional system of planting are presented in Table 4.11 and 4.22. The data showed that the application of different plant growth regulators at various concentrations had significantly increased the yield of guava over control in the present investigation. Among the various plant growth regulator treatments attempted under high density planting system the mean maximum yield 39.28 kg / plant (43.63 tonnes / ha.) was recorded at 500 ppm paclobutrazol followed by 250 ppm paclobutrazol treatment (Table 4.11). The mean minimum yield (26.25 kg / plant and 29.16 tonnes / ha.) was observed at control. Similarly, under traditional system of planting the mean highest yield (63.83 kg / plant and 17.74 tonnes / ha.) was recorded at 500 ppm paclobutrazol, followed by 200 ppm NAA and 250 ppm paclobutrazol treatments (Table 4.22). However the mean lowest yield of guava (45.67 kg / plant and 12.69 tonnes / ha.) was obtained at control.

The increase in yield of guava by application of paclobutrazol and NAA may be attributed to the fact that partitioning of assimilates by paclobutrazol and NAA more towards the fruit development which may leads to improvement in yield contributing characters like size and weight of fruits as evident by the present study which ultimately increased the yield (Anbu *et al.*, 2001 and Sarkar *et al.*, 1998) in mango. Similar results were also observed by application of cultar (PBZ) in mango (Singh & Dhillon, 1992), in apple (Tao *et al.*, 1998), in red raspberry (Ghora *et al.*, 2000) and in plum (Lin *et al.*, 2000).

5.6 Economics of the treatment used

The economics of different plant growth regulator treatments used at various concentrations in the present investigation under high density and traditional system of planting are calculated and presented in Table 5.1 and 5.2, respectively. In case of high density planting system, the economic feasibility of various treatments clearly showed that the application of 500 ppm paclobutrazol treatment has resulted the maximum gross return of Rs. 2,61,780/ha which was Rs. 86,820/ha excess over control. Further, the highest net profit (Rs. 72,476/ha) was estimated at 500 ppm paclobutrazol treatment which was 41.42 per cent higher than control. Similar trends of highest gross return (Rs. 1,06,440/ha) net profit (Rs. 24,140/ha) and per cent increase in net profit (31.70%) over control were estimated due to application of 500 ppm paclobutrazol treatment under traditional system of planting.

The highest percent increase in net profit in both the system of planting as a result of 500 ppm PBZ treatment may be because of highest yield of qualitative fruits under this treatment as evident from the present results discussed earlier in the text. Therefore, among the various plant growth regulator treatments attempted under present investigation, the application of 500 ppm

PBZ was found to be most economic and desirable treatment both under high density and traditional system of planting.

From the far going discussion, it became quite clear that comparison between the two different system of planting (i.e. high density and traditional system) suggests that in general the high density planting system gave higher yield/ha of guava cv. 'Sardar' fruit compare to traditional system of planting. For example the maximum yield of 43.63 tonnes/ha was recorded due to application of 500 ppm paclobutazol treatment under high density planting system as compare to 17.74 tonnes/ha under traditional system of planting even after the same treatment was applied at the same time. It is basically, because of less number of plants/ha (278/ha) under traditional system. These results are corroborated with the findings of Panday *et al.* (1997) they reported that fruit yield/plant was decreased with increasing plant density but fruit yield/ha, total yield and net profit all increased with increasing plant density in guava orchard. Similarly, Shant *et al.* (1996) found that spacing dose not significantly affected fruit set and flower/fruit drop in guava. However, trees at 2 X 2 m had a lower yield/tree than those at 8 X 8 m but 10 fold higher yield/ha.

The relative economics of the various plant growth regulator treatments was also worked out under both the system of planting. On the basis of relative economics it can again be suggested that 500ppm PBZ treatment was found to be most effective and desirable on the basis of early maturity and highest yield coupled with superior nutritional qualities of guava cv. 'Sardar' fruit under high density planting system rather than traditional system of planting. Thus, a result of the present investigation leads to following important findings.

- (1) Among the various plant growth regulators tried, paclobutrazol and NAA were found to be most effective for increasing the yield of guava cv. 'Sardar' fruit.
- (2) High density planting system was proved to be superior over traditional system of planting with respect to yield per ha of guava cv. 'Sardar'.
- (3) A non-significant effect was observed between the concentrations of various plant growth regulators tried thereby, inducting that the effect of lower concentration was as good as that of the higher concentration.
- (4) Of the two most effective treatment i.e. 500 ppm PBZ and NAA 200 ppm, the paclobutrazol treatment is economically cheaper than NAA.

Therefore, based on the findings the guava growers may be advised to preferably spray the guava plant with 500 ppm paclobutrazol in the month of July to get better yield of winter

season guava crop with superior quality. Further more, it is suggested that in future research can be initiated on the following lines.

- (1) Some more concentrations of PBZ and NAA may be tried so as to increase the yield over control.
- (2) Paclobutrazol might be used in rainy season crop to improve quality and quantity of fruits.
- (3) Treatments tried in the present investigation may be confirmed by applying in some other varieties of guava including latest hybrids.
- (4) Similar studies can also be extended to guava orchard where such work has not been done.
- (5) It can also be investigated that up to how many years paclobutrazol will keep continue to improving the yield of guava with this rate of increment.

4. RESULTS

Results of the experiment entitled “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting” conducted for two consecutive years of 2002-03 and 2003-04 are being presented in this chapter. Data related to various parameters used for evaluation of treatments were statistically analysed using pooled analysis in completely Randomized Block Design and analysis of variance for these data have been furnished in Appendices – I to XXII.

Interpretation of data has been made on pooled basis, highlighting the significant effect of treatments. Wherever required photo plates have also been inserted to provide further support to the results.

4.1 Experiment I : Effect of Plant Growth Regulators on Growth, Yield and Quality of Guava (*Psidium guajava* L.) cv. ‘Sardar’ Under High Density Planting System

The findings of an investigation entitled “**Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density planting system**” is presented in the first part of this chapter. The results have been explained by applying the statistical analysis of data for convenience of easy grasp and understanding. Certain findings have been illustrated by suitable diagrams/graphs also whenever necessary.

4.1.1 Vegetative growth characters

The effect of various plant growth regulator treatments on vegetative growth characters such as per cent increase in shoot length, per cent increase in shoot diameter and number of leaves/shoot of guava were studied and periodical observation of these characters were recorded at 15 days interval for a total period of 75 days from date (16 July) of treatment after recording the initial observation and presented in Table 4.1 to 4.3 and depicted in Fig. 4.1 to 4.3. The analysis of variance of these characters are given in Appendices I to III.

4.1.1.1 Shoot length :

Data pertaining to per cent increase in shoot length have been presented in Table 4.1 and depicted in Fig. 4.1. The analysis of variance is given in Appendix – I. The critical evaluation of data indicates that all the plant growth regulators had significantly influenced the rate of increase in shoot length as compared to control. Whereas, the shoot length was significantly reduced due to Ethrel, PBZ and CCC treatments at different concentrations over control. However, on the 75th

day after application of treatments the mean maximum increase in shoot length (46.25%) was observed in 100 ppm NAA followed by 200 ppm NAA (45.24%) which were significantly higher than control and rest of the treatments under study. The mean minimum increase in shoot length (33.10%) was observed in 1000 ppm CCC treatment and followed by 500 ppm PBZ (33.14%) treatments which were statistically at par.

4.1.1.2 Shoot diameter :

The data related to per cent increase in shoot diameter as affected by different plant growth regulators are presented in Table 4.2 and depicted in Fig. 4.2. The analysis of variance is given in Appendix – II.

The application of different plant growth regulators showed significant effect on per cent increase in shoot diameter during both the year of experimentation i.e. 2002-03 and 2003-04 on all the days of observation from 15th to 75th day after treatments. The analysis of pooled mean data of two years was also showed significant effect of plant growth regulators on shoot diameter. On 75th day after treatment, the mean maximum increase in shoot diameter was observed in 1000 ppm CCC (39.15%) treatment followed by 200 ppm NAA (38.98%) and 500 ppm paclobutrazol (38.94%) treatments as compared to mean minimum in control (36.25%) which was significantly lower than all other treatments under study.

4.1.1.2 Number of leaves :

The data on effect of plant growth regulator treatments on number of leaves/shoot are presented in Table 4.3 and depicted in Fig. 4.3. The analysis of variance of these data is given in Appendix – III. The application of plant growth regulator treatments showed significant effect on number of leaves/shoot during both the year of investigation as well as on their pooled means, on all the days of observations (i.e. 15, 30, 45, 60 and 75 days after treatments).

However, the mean maximum increase in number of leaves/shoot i.e. 7.06 (from 6.52 to 13.58) was observed in 200 ppm NAA treatment followed by 100 ppm NAA i.e. 6.82 (from 6.40 to 13.22) and 10 ppm triacontanol i.e. 6.76 (from 6.17 to 12.93) treatments on 75 days after treatments. Whereas, the mean minimum increase in number of leaves/shoot was observed in 1000 ppm CCC i.e. 5.96 (from 6.40 to 12.36) followed by 500 ppm PBZ i.e. 6.02 (from 6.13 to 12.15) treatments.

4.1.2 Flowering and fruiting characters :

The effect of plant growth regulators at different concentration on flowering and fruiting characters like days taken to initiation of flowering, number of flowers per shoot, per cent fruit set, per cent fruit retention and days taken to harvesting were studied under high density planting

system. The data recorded on these aspects are presented in Table 4.4 to 4.5 and depicted in Fig. 4.4 to 4.5. The analysis of variance of these characters has been presented in Appendices IV to V.

4.1.2.1 Days taken to initiation of flowering :

The data on days taken to initiation of flowering as affected by various plant growth regulator treatments are presented in Table 4.4 and depicted in Fig. 4.4(a). The analysis of variance has been presented in Appendix – IV. A perusal of data reveals that days taken to initiation of flowering was significantly decreased by the application of different plant growth regulator treatments.

The mean minimum days taken to initiation of flowering after treatment was obtained in 1000 ppm CCC (27.50) which was statistically at par with 500 ppm PBZ (27.67 days), 500 ppm ethrel (28.16 days), 250 ppm ethrel and 200 ppm NAA (28.50 days) treatments. However, the mean maximum days taken to initiation of flowering (35.50 days) was obtained in control which was significantly higher than other treatments attempted in the present study.

4.1.2.2 Number of flowers per shoot :

The data on number of flowers/shoot as influenced by different plant growth regulator treatments are given in Table 4.4 and depicted in Fig. 4.4(b). The analysis of variance is presented in appendix – IV.

The application of plant growth regulators significantly increased the number of flowers/shoot over control during both the year of studies i.e. 2002-03 and 2003-04. The analysis of pooled data also showed significant difference in number of flowers/shoot. The mean maximum number of flower (7.23/shoot) were counted in 500 ppm ethrel treatment which is statistically at par with 500 ppm PBZ (7.50/shoot), 200 ppm NAA (7.23/shoot) and 1000 ppm CCC (7.10/shoot) treatments. While the mean minimum number of flowers were obtained (4.77/shoot) in control.

4.1.2.3 Fruit set :

The data on per cent fruit set as affected by different plant growth regulators treatments are presented in Table 4.5 and depicted in Fig 4.5(a). The analysis of variance has been given in Appendix V. The application of various plant growth regulator treatments has significantly increased the fruit set percentage over control.

The pooled analysis of two years also showed significant effect on per cent fruit set. However, the mean maximum fruit set (71.78%) was observed in 500 ppm paclobutrazol

treatment which was significantly higher than control and other treatments. Whereas, the mean minimum fruit set (58.89%) was recorded in control.

4.1.2.4 Fruit retention :

The data on per cent fruit retention as affected by various plant growth regulator treatments are presented in Table 4.5 and depicted in Fig. 4.5(b). The analysis of variance is given in Appendix V.

A perusal of data reveals that per cent fruit retention was significantly increased as a result of different plant growth regulator treatments during year 2002-03. While in the year 2003-04, it was found to be non-significant. Nevertheless the pooled analysis of two years mean data were found to be significant in this regard. The mean maximum fruit retention (70.67%) was observed in 500 ppm PBZ treatment which was significantly superior to all the treatments including control. The mean minimum fruit retention (62.90%) was recorded in control.

4.1.2.5 Days taken to harvesting :

The data on days taken to harvesting as influenced by various plant growth regulator treatments are presented in Table 4.4 and depicted in Fig. 4.4(c). The analysis of variance has been given in Appendix – IV. It is evident from the data that days taken to harvesting was significantly decrease due to application of different plant growth regulator treatments over control during both the year of study (2002-03 and 2003-04) under high density planting system of guava.

The pooled analysis of two years mean data also showed the significant reduction in the days taken to harvesting over control as a result of various treatments. The mean minimum days taken to harvesting (115 days) was observed in 500 ppm ethrel treatment which was significantly lower than all other treatments. However, the mean maximum days taken to harvesting (126.16 days) recorded in control.

4.1.3 Physical characteristics of fruits

The effect of plant growth regulators at different concentration on physical characteristics of guava fruit like length, diameter, weight, volume, specific gravity and organoleptic rating were studied under high density planting system and the data recorded on these aspects are given in Table 4.6 to 4.7 and depicted in Fig. 4.6 to 4.7. The analysis of variance for these characters has been presented in Appendices VI to VII.

4.1.3.1 Length of fruit :

The data presented in Table 4.6 and depicted in Fig. 4.6(a) showed that length of fruit was significantly affected as a result of different plant growth regulator treatments (Appendix – VI) during both the year of experimentation i.e. 2002-03 and 2003-04. The pooled analysis of two year mean data on length of fruit as affected by different plant growth regulator treatments were also found significant over control. An evaluation of data showed that application of plant growth regulator treatments has increased the length of fruit significantly over control.

The mean maximum length of fruit (7.40 cm) was observed in 500 ppm paclobutrazol treatment which was closely followed by 500 ppm NAA (7.12 cm) treatment and both are found statistically at par. Whereas, the mean minimum length of fruit (5.85 cm) was recorded in control which is closely followed by 500 ppm ethrel (5.86 cm) and 250 ppm ethrel (6.07 cm) treatments.

4.1.3.2 Diameter of fruit :

The result obtained on diameter of fruit as influenced by different plant growth regulator treatments and presented in Table 4.6 and depicted in Fig. 4.6(b). The analysis of variance has been given in Appendix – VI. The diameter of fruit was significantly increased as a result of different plant growth regulator treatments in both the year of experiment i.e. 2002-03 and 2003-04. The pooled analyses of two years mean data were also showed significant effect of plant growth regulator treatments on diameter of fruit.

However, the mean maximum diameter of fruit (7.30 cm) was recorded in 200 ppm NAA treatment which was closely followed by 500 ppm PBZ (7.23 cm) and 100 ppm NAA (7.04 cm) treatment. The mean minimum diameter of fruit (5.94 cm) was obtained in control followed by 500 ppm ethrel (6.01 cm) and 250 ppm ethrel (6.16 cm) treatments.

4.1.3.3 Organoleptic score/rating :

The data on effect of plant growth regulators on organoleptic rating of guava fruit are presented in table 4.6 and depicted in fig 4.6(c). The analysis of variance is given in Appendix – VI. A perusal of data reveals that the application of different plant growth regulator treatments had significantly improve the organoleptic score of freshly harvested fruits during both the year of experimentation (2002-03 and 2003-04). The pooled analysis of two years mean data were also found to be significant on organoleptic score of fruits.

The mean maximum organoleptic score (8.87) was recorded in 500 ppm ethrel and followed by 250 ppm ethrel (8.50) and 500 ppm PBZ (8.36) treatments. Whereas, the mean minimum organoleptic score (6.75) was observed in control which was significantly lower than other treatments expect triacontanol 5 ppm (7.12).

4.1.3.4 Weight of fruit :

The data on weight of fruit as affected by various plant growth regulator treatments are presented in table 4.7 and depicted in Fig. 4.7(a). The analysis of variance has been given in Appendix – VII. The applications of plant growth regulators had a significant effect on weight of fruit during both the year of investigation (i.e. 2002-03 and 2003-04) and in pooled analysis of two years mean data also.

The weight of fruit significantly increased by application of different plant growth regulator treatments. The mean highest weight of fruit (191.46 g) was recorded in 500 ppm PBZ treatment which was significantly higher than other treatments under study. However, the mean lowest weight of fruit (139.42g) was observed in control followed by 250 ppm ethrel and 500 ppm ethrel treatments (i.e. 142.21 and 142.02g respectively).

4.1.3.5 Volume of fruit :

It is evident from the data presented in Table 4.7 and depicted in Fig. 4.7(b) that the volume of fruit was significantly affected by application of different plant growth regulator treatments. The application of plant growth regulator treatments significantly increased the volume of fruit over control (Appendix – VII).

The mean maximum volume of fruit (188.16 cc) was reported in 500 ppm PBZ treatment followed by 200 ppm NAA (178.95 cc) as compare to mean minimum volume of fruit (129.31 cc) in control. However, the difference in 250 ppm ethrel (E₁), 500 ppm ethrel (E₂), 5 ppm triacontanol (T₁) and control treatments were found to be non-significant.

4.1.3.6 Specific gravity :

The data on specific gravity as influenced by different plant growth regulator treatments are presented in Table 4.7 and depicted in Fig. 4.7(c). The analysis of variance is given in appendix – VII.

The specific gravity of fruit was significantly decreasing due to application of plant growth regulators during both the years of studies. However, the mean minimum specific gravity (1.018 g/cc) was obtained in 500 ppm PBZ treatment followed by 200 ppm NAA (1.019 g/cc) and 250 ppm ethrel (1.021 g/cc) treatments as compare to mean maximum (1.078g/cc) in control. This was significantly higher than other treatments attempted under present investigation.

4.1.4 Chemical characteristics of fruit

The effect of different concentrations of plant growth regulator treatments under high density planting system on chemical characteristics of guava fruit like total soluble solids, acidity, TSS/acid ratio, ascorbic acid, pectin content and sugar content (reducing, non-reducing

and total sugar) were studied in the present experiment. The data are presented in Table 4.8 to 4.10 and depicted in Fig 4.8 and 4.10. The analysis of variance is given in Appendices VIII to X.

4.1.4.1 Total soluble solids :

The data on TSS as affected by different plant growth regulator treatments are presented in Table 4.8 and depicted in Fig. 4.8(a). The analysis of variance has been given in Appendix – VIII. The application of plant growth regulator treatment significantly increased the TSS content of fruit over control during both the year of studies i.e. 2002-03 and 2003-04.

The mean maximum total soluble solid (15.66%) was recorded in 500 ppm ethrel treatment followed by 500 ppm PBZ and 250 ppm ethrel i.e. 14.70 per cent and 14.63 per cent respectively. However, the mean minimum TSS content of fruit (12.15%) was recorded in control, which was significantly lower than other treatments.

4.1.4.2 Acidity :

The data on acidity of fruit as affected by different plant growth regulator treatments are highlighted in table 4.8 and depicted in Fig. 4.8(b). The analysis of variance has been given in Appendix – VIII.

The acidity of fruit was significantly decreased by application of various plant growth regulators during both the year of investigations i.e. 2002-03 and 2003-04 as compared to control. However, the mean maximum acidity (0.610%) was recorded in control as compared to mean minimum (0.390%) in ethrel 500 ppm (E₂) treatment. The data further indicates that the acidity of the fruits under the treatments of 200 ppm NAA, 250 ppm ethrel and 500 ppm PBZ were found significantly lower than control but the difference within these treatments was found to be non-significant.

4.1.4.3 TSS / acid ratio :

The data on TSS / acid ratio of fruit as influenced by different plant growth regulator treatments are presented in Table 4.8 and depicted in Fig. 4.8(c). The analyses of variance of these data are given in Appendix – VIII. The application of plant growth regulator treatments had significantly increased TSS / acid ratio of fruit over control.

The maximum TSS/acid ratio (40.40) of fruit was recorded in 500 ppm ethrel treatment which was significantly higher than all the treatments. Whereas, the mean minimum TSS / acid ratio (20.05) of fruit was observed in control.

4.1.4.4 Ascorbic acid content of fruit (mg/100 g pulp) :

The data on ascorbic acid content of fruit as affected by various plant growth regulator treatments are presented in Table 4.9 and depicted in Fig. 4.9(a). The analysis of variance has been presented in Appendix – IX. A perusal of data reveals that ascorbic acid content of fruit was significantly increased as a result of different plant growth regulator treatments during both the year (2002-03 and 2003-04).

The mean maximum ascorbic acid content (210.82 mg/100 g pulp) was recorded in 500 ppm PBZ which was closely followed by 200 ppm NAA (208.37 mg/100 g pulp) and 250 ppm PBZ (207.11 mg/100 g pulp) treatments, it indicates that these treatments were statistically at par and significantly higher than all other treatments. While the mean minimum ascorbic acid content (174.02 mg/100 g pulp) was recorded in control.

4.1.4.5 Pectin content :

The data on pectin content of fruit as influenced by different plant growth regulator treatments are presented in Table 4.9 and depicted in Fig 4.9(b). The analysis of variance has been presented in Appendix – IX. The pectin content of guava fruit was significantly increased due to application of plant growth regulator treatments over control during both the year.

The mean maximum pectin content of fruit (0.775%) was observed in 500 ppm PBZ treatment followed by 200 ppm NAA (0.761%) and 100 ppm NAA (0.741%) treatments. The mean minimum pectin content (0.606%) was recorded in control.

4.1.4.6 Reducing sugar :

The data on reducing sugar content of fruit as affected by different plant growth regulator treatments are presented in Table 4.10 and depicted in Fig. 4.10(a). The analysis of variance has been presented in Appendix – X. It is evident from the data that reducing sugar content of fruit was significantly increased due to application of plant growth regulators during both the year i.e. 2002-03 and 2003-04. A significant effect of plant growth regulator on reducing sugar content of fruit was also recorded in pooled analysis of the data. The mean maximum reducing sugar content (4.58%) was observed in 500 ppm ethrel as compared to mean minimum (3.93%) in control.

4.1.4.7 Non-reducing sugar :

The data on non-reducing sugar content of fruit as affected by various plant growth regulator treatments are presented in table 4.10 and depicted in Fig. 4.10(b). The analysis of variance has been given in Appendix – X. A perusal of data reveals that non-reducing sugar

content of fruit was significantly increased as a result of different plant growth regulator treatments.

However, in the first year (i.e. 2002-03) it was found to be non-significantly influenced by use of different plant growth regulator treatments. Whereas, in the second year (i.e. 2003-04) effect of plant growth regulators was found to be significant in increasing the non-reducing content of fruit. The mean maximum non-reducing sugar (3.11%) was obtained in 500 ppm ethrel treatment as compared to mean minimum (2.36%) in control which was closely followed by 5 ppm triacontanol (2.42%) and 10 ppm triacontanol (2.51%) treatments.

4.1.4.8 Total sugar :

The data on total sugar content of fruit as influenced by different plant growth regulator treatments are presented in Table 4.10 and depicted in Fig 4.10(c). The analysis of variance is given in Appendix – X. The application of plant growth regulator treatments exerted significant effect on total sugar content of fruit during both the year of experiments (i.e. 2002-03 and 2003-04). The total sugar content of fruit was increased due to all the treatments of plant growth regulator attempted in the present investigation.

The mean maximum total sugar (7.86%) was recorded in 500 ppm ethrel. Whereas, mean minimum total sugar content (6.43%) was recorded in control which was found to be significantly lower than other treatments.

4.1.5 Yield

The effect of different concentration of plant growth regulators on fruit yield of guava under high density planting system (kg/plant and tones/ha) were studied and the data are presented in Table 4.11 and depicted in Fig. 4.11(a) and (b). The analysis of variance is given in Appendix – XI.

The application of plant growth regulator treatments significantly increased the yield (kg/plant and tones/ha) of guava during both the year of studies (i.e. 2002-03 and 2003-04). However, mean maximum yield (39.28 kg/plant and 43.63 tonnes/ha) was recorded in 500 ppm PBZ treatment which was significantly higher than all other treatments. The mean minimum yield (26.25 kg/plant and 29.16 tonnes/ha) was obtained in control.

4.2 Experiment II : Effect of Plant Growth Regulators on Growth, Yield and Quality of Guava (*Psidium guajava* L.) cv. ‘Sardar’ under Traditional System of Planting

The findings of an investigation entitled “**Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under traditional system of planting**” is presented in this part. The results have been explained by applying the statistical analysis of data for convenience of easy grasp and understanding. Certain findings have been illustrated by suitable diagrams/graphs also whenever necessary.

4.2.1 Vegetative growth characters

The effect of various plant growth regulators at different concentration on vegetative growth characters such as per cent increase in shoot length, per cent increase in shoot diameter and number of leaves/shoot of guava were studied and periodical observation of these characters were recorded at 15 days interval for a total period of 75 days from date (16 July) of treatment after recording the initial observation and presented in Table 4.12 to 4.14 and depicted in Fig. 4.12 to 4.14. The analyses of variance of these characters are given in Appendices XII to XIV.

4.2.1.1 Shoot length :

Data pertaining to per cent increase in shoot length have been presented in Table 4.12 and depicted in Fig. 4.12. The analysis of variance is given in Appendix – XII.

The critical evaluation of data indicates that all the plant growth regulators had significantly influenced the rate of increase in shoot length over control. It is evident from the data that application of NAA and triacontanol treatments showed significantly higher rate of increase in shoot length over control. On the contrary, the rate of increase in shoot length was significantly reduced as a result of ethrel, PBZ and CCC treatments during both the year of experimentation i.e. 2002-03 and 2003-04.

However, the pooled analysis of two year data showed mean highest increase in shoot length (36.96%) at 100 ppm NAA treatment as compared to minimum (27.49%) in 500 PBZ treatment followed by 1000 ppm CCC (28.40%) treatment on 75th days after spray of plant growth regulators.

4.2.1.2 Shoot diameter :

A perusal of data presented in Table 4.13 and depicted in Fig. 4.13 reveals that shoot diameter increased with the advancement of growth period irrespective of treatments from 15th to 75th days after spray of plant growth regulators.

The per cent increase in shoot diameter was significantly affected by various plant growth regulator treatments in both the years of experimentation (Appendix – XIII). However, on 75 days after treatments the mean maximum increase in shoot diameter (36.55%) was recorded in 500 ppm PBZ treatment which was closely followed by 1000 ppm CCC (35.94%), which were significantly higher than other treatments.

The mean minimum increase in per cent shoot diameter was recorded in control (32.26%) followed by 5 ppm triacontanol (33.81%) treatment.

4.2.1.3 Number of leaves / shoot :

It is evident from the data that the number of leaves growing shoot increased with the advancement of growth period during experimentation period up to 75 days after treatment in both the year i.e. 2002-03 and 2003-04 and it was significantly affected by various plant growth regulator treatments (Table 4.14 and Fig. 4.14). The analysis of pooled data of two year also resulted significant affect of plant growth regulators on number of leaves / growing shoot (Appendix – XIV).

It is clear from the data that the application of NAA and triacontanol at different concentration had significantly increased the number of leaves/shoot as compared to control and other treatments. The mean maximum increase in number of leaves of 6.91 (from 6.04 to 12.95) was recorded in 10 ppm triacontanol treatment which was closely followed by 5 ppm triacontanol i.e. 6.81 (from 6.17 to 12.98). Mean minimum increase in number of leaves i.e. 5.21 (5.99 to 11.20) was observed in 500 ppm PBZ treatment and which was statistically at par with 250 ppm PBZ i.e. 5.32 (from 5.94 to 11.26). However, the difference in 250 ppm ethrel and 500 ppm CCC treatment was found to be non-significant at 75 days after treatment.

4.2.2 Flowering and fruiting characters

The effect of plant growth regulators at different concentration on flowering and fruiting characters like days taken to initiation of flowering, number of flowers per shoot, per cent fruit set, per cent fruit retention and days taken to harvesting were studied under traditional system of planting. The data recorded on these parameters are presented in Table 4.15 to 4.16 and Fig. 4.15 to 4.16. The analysis of variance of these characters has been presented in Appendices XV to XVI.

4.2.2.1 Days taken to initiation of flowering :

The data on days taken to initiation of flowering as affected by various plant growth regulator treatments are presented in Table 4.15 and depicted in Fig. 4.15(a). The analysis of variance is given in Appendix – XV. A perusal of data reveals that, days taken to initiation of

flowering was significantly decreased as a result of various plant growth regulator treatments at different concentration as compared to control.

The mean minimum days taken to initiation of flowering after various plant growth regulator treatments was obtained in 500 ppm ethrel and 500 ppm PBZ (29.0 days) treatments followed by 200 ppm NAA (30.16 days) and 1000 ppm CCC (30.33 days) treatments. However, the difference in 250 ppm ethrel, 500 ppm CCC, 250 ppm PBZ and 100 ppm NAA treatments were found to be non-significant indicating that these treatments are statistically at par.

The mean maximum days taken to initiation of flowering was recorded in control (38.0 days), which is significantly higher than the other treatments.

4.2.2.2 Number of flowers / shoot :

The data on number of flowers/shoot as influenced by different plant growth regulators treatments are presented in table 4.15 and depicted in Fig. 4.15(b). The analysis of variance is given in Appendix – XV. The application of plant growth regulators showed a significant effect on number of flowers/shoot in both the years 2002-03 and 2003-04.

Similarly, the pooled analysis of two year means data were also found to be significantly affected the number of flowers/shoot. The number of flowers was increased in all the treatments of plant growth regulator at different concentration over control.

The mean maximum numbers of flowers/shoot was obtained in 500 ppm PBZ (7.77) treatment which was closely followed by 500 ppm ethrel (7.73), 1000 ppm CCC (7.63) and 200 ppm NAA (7.53) treatments. However, these treatments are statistically at par. The minimum number of flowers/shoot was obtained in control (5.30), which was significantly lower than other treatments.

4.2.2.3 Fruit set :

The data on per cent fruit set as affected by various plant growth regulator treatments are given in Table 4.16 and depicted in Fig. 4.16(a). The analysis of variance is given in Appendix – XVI.

As evident from the data that application of plant growth regulator treatment had the significant effect on per cent fruit set during both the year of experimentation. Fruit set per cent was increased in all the treatments of plant growth regulators at various concentrations over control. However, the mean maximum fruit set (71.17%) was observed in 500 ppm PBZ followed by 1000 ppm CCC (69.73%) treatment. The mean minimum fruit set (57.50%) was recorded in control, which was significantly lower than all other treatments under the study.

4.2.2.4 Fruit retention :

The data on per cent fruit retention as influenced by plant growth regulator treatments are presented in Table 4.16 and depicted in Fig. 4.16(b). The analysis of variance is given in Appendix – XVI.

From the table it can be observed that there was significant difference on per cent fruit retention due to plant growth regulators treatment in the year 2002-03 and pooled analysis of both the years. However, in the year 2003-04 it was found to be non-significant. The mean maximum fruit retention (73.16%) was obtained in 500 ppm PBZ treatment followed by 200 ppm NAA (70.39%) and 250 ppm PBZ (70.13%) treatments. While, the mean minimum fruit retention (65.03%) was observed in control which was statistically at par to 500 ppm ethrel (66.42%) and 250 ppm ethrel (66.81%) treatments.

4.2.2.5 Days taken to harvesting :

The data on days taken to harvesting as influenced by various plant growth regulator treatments are presented in Table 4.15 and Fig. 4.15(c). The analysis of variance is given in Appendix – XV. The application of plant growth regulators had a significant effect on days taken to harvesting (maturity days) during both the year of experimentation. The days taken to harvesting were reduced due to different treatments of plant growth regulators at various concentrations over control.

The pooled data of both the years reveals that minimum days taken to harvesting was recorded in 500 ppm PBZ (115.33days) followed by 500 ppm ethrel (115.50days) and 250 ppm ethrel (117.5days) treatments which were significantly lower than rest of the other treatments. The mean maximum number of days taken to harvesting of fruit was recorded in control (126.0days) followed by 5 and 10 ppm triacontanol treatments i.e. 123.33 and 121.67 days, respectively.

4.2.3 Physical characteristics of fruit

The effect of plant growth regulators at different concentration on physical characteristics of guava fruits such as length of fruit, diameter of fruit, weight of fruit, volume of fruit, specific gravity of fruit and organoleptic rating of fruit were studied and data are presented in Table 4.17 to 4.18 and Fig 4.17 to 4.18. The analyses of variance of these characters are given in Appendices XVII to XVIII.

4.2.3.1 Length of fruit :

The data on length of fruit as influenced by various plant growth regulator treatments are presented in Table 4.17 and depicted in Fig 4.17(a). The analysis of variance is given in Appendix – XVII.

The critical examination of data reveals that the length of fruit increased with the application of NAA, PBZ, CCC and triacontanol at different concentrations over control and ethrel treatment. The mean maximum length of fruit (6.67 cm) was obtained in 500 ppm PBZ treatment, which is statistically at par with 200 ppm NAA, 250 ppm PBZ and 1000 ppm CCC treatments. The mean minimum length of fruit was recorded in 500 ppm ethrel (5.65 cm) which was closely followed by control (5.67 cm) and 250 ppm ethrel (5.72 cm) treatments.

4.2.3.2 Length of fruit :

The data on diameter of fruit as affected by various plant growth regulator treatments are given in Table 4.17 and depicted in Fig. 4.17(b). The analysis of variance of these data are given in Appendix – XVII.

The application of plant growth regulators exerted significant difference on diameter of fruits in both the years and pooled analysis. The mean maximum diameter of guava fruit (6.74 cm) was observed in 500 ppm PBZ treatment, which was closely followed by 200 ppm NAA (6.64 cm) treatment. However, the difference in these two treatments was found to be non-significant. On the other hand, the mean minimum diameter of fruit was observed in 500 ppm ethrel (5.69 cm) treatment followed by control (5.71 cm) and 250 ppm ethrel (5.77) treatments.

4.2.3.3 Organoleptic rating :

The data related to organoleptic rating of guava fruits as influenced by various plant growth regulator treatments are given in Table 4.17 and depicted in Fig. 4.17(c). The analysis of variance is given in Appendix – XVII.

The data recorded in present investigation reveals that organoleptic score of guava fruit was significantly increased due to application of various plant growth regulators over control. The mean maximum organoleptic score (8.67) of guava fruit was observed in 500 ppm ethrel treatment followed by 250 ppm ethrel (8.33) and 500 ppm PBZ (8.20) treatments which were statistically at par. While, the mean minimum organoleptic score of guava fruits (6.25) was recorded in control, which was significantly lower than all other treatments.

4.2.3.4 Weight of fruit :

The data related to weight of fruit as affected by plant growth regulator treatments are enumerated in Table 4.18 and depicted in Fig 4.18(a). The analysis of variance is given in Appendix – XVIII.

It is clear from the data that the weight of fruit was significantly increased by the application of different plant growth regulators over control except 250 and 500 ppm ethrel and 5 ppm triacontanol treatments. However, among all the treatments attempted, the mean maximum

weight of guava fruit (179.32 g) was recorded in 500 ppm PBZ treatment followed by 200 ppm NAA (172.92 g). Whereas, mean minimum weight of fruit was recorded in control (132.46 g).

4.2.3.5 Volume of fruit :

The data on volume of fruit as influenced by different plant growth regulator treatments are presented in Table 4.18 and depicted in Fig. 4.18(b). The analysis of variance is given in Appendix – XVIII.

It is evident from the data that volumes of fruit was significantly influenced by application of plant growth regulator treatments during both the year i.e. 2002-03 and 2003-04 as well as pooled analysis. However, the mean maximum volume of fruit (172.45 cc) was observed in 500 ppm PBZ treatment followed by 200 ppm NAA (165.47 cc) treatment which were significantly higher than control and other treatments. The mean minimum volume of fruit was recorded in control (118.56 cc) which was significantly lower than all the treatment used in the present experiment.

4.2.3.6 Specific gravity :

The data on specific gravity of fruits as affected by various plant growth regulator treatments under traditional system of planting are presented in Table 4.18 and depicted in Fig. 4.18(c). The analysis of variance is given in Appendix – XVIII.

The result reveals that the application of plant growth regulator treatments had significant effect on specific gravity of fruit. The mean minimum specific gravity of fruit (1.038 g/cc) was recorded in 250 ppm ethrel treatment which was closely followed by 500 ppm PBZ (1.040 g/cc) and 500 ppm ethylene (1.049 g/cc) treatments. However, the mean maximum specific gravity of fruit was obtained in control (1.118 g/cc) which was significantly higher than all other treatments.

4.2.4 Chemical characteristics of fruit

The effect of various plant growth regulator treatments at different concentrations on chemical characteristics of fruit like total soluble solids (TSS), acidity, TSS/acid ratio, ascorbic acid (Vit – C), pectin content and sugar content (reducing, non-reducing and total sugar) were studied and the data are present in Table 4.19 to 4.21 and depicted in Fig. 4.19 to 4.21. The analysis of variance for these characters are given in Appendices XIX to XXI.

4.2.4.1 Total soluble solids :

The data in TSS as affected by different plant growth regulator treatments are presented in Table 4.19 and depicted in Fig. 4.19(a). The analysis of variance is given in Appendix – XIX.

The application of plant growth regulators had significantly increases the TSS content of fruit over control. The mean maximum TSS content of fruit was observed in 500 ppm ethrel (15.35%) followed by 500 ppm PBZ (14.70%) and 250 ppm ethrel (14.25%) treatments. Whereas, the mean minimum TSS content was recorded in control (11.75%) which was significantly lower than all treatments.

4.2.4.2 Acidity :

The data on acidity of fruit as affected by different treatments of plant growth regulators are presented in Table 4.19 and depicted in Fig. 4.19(b). The analysis of variance is given in Appendix – XIX.

The data on acidity of guava fruit as influenced by plant growth regulators reveals that the acidity of fruit was significantly reduced by various treatments. Whereas, the mean minimum acidity of fruit (0.375%) was recorded in 500 ppm ethrel treatment followed by 250 ppm ethrel and 500 ppm PBZ (0.40%) treatments. While, the mean maximum acidity (0.565%) was obtained in control fruits which was significantly higher than all the plant growth regulator treatments.

4.2.4.3 TSS / acid ratio :

The data of TSS/Acid ratio as influenced by different treatments of plant growth regulators are presented in Table 4.19 and depicted in Fig. 4.19(c). The analysis of variance is given in Appendix – XIX. The TSS/Acid ratio of fruit was significantly increased due to application of plant growth regulators over control during both the year of studies under traditional system of planting.

The mean maximum TSS/Acid ratio fruit (40.97) was observed in 500 ppm ethrel which was significantly higher than all other treatments. While, the mean minimum TSS/Acid ratio (21.04) was obtained in control and significantly lower than all the other treatments.

4.2.4.4 Ascorbic acid (vit – c) :

The data on effect of plant growth regulator treatments on ascorbic acid content of guava fruits are presented in Table 4.20 and depicted in Fig. 4.20(a). The analysis of variance is given in Appendix – XX. The application of plant growth regulators had significantly increased ascorbic acid content of guava fruits during both the year of investigation i.e. 2002-03 and 2003-04.

However, the mean data of two years resulted highest ascorbic acid content of guava fruit was observed in 200 ppm NAA (205.18 mg/100 g pulp) treatment which was statistically

superior over all the other treatments. Whereas, the mean lowest ascorbic acid content (175.06 mg/100 g pulp) of fruit was recorded in control.

4.2.4.5 Pectin content :

The data presented in Table 4.20 and depicted in Fig. 4.20(b) reveals that the application of different plant growth regulator treatments in guava had significant effect on pectin content of fruit during both the year of experimentation (2002-03 and 2003-04). The analysis of variance is given in Appendix – XX.

The pectin content of fruit was significantly increased in all plant growth regulator treatments over control. The analysis of pooled data of two year showed that the mean maximum pectin content (0.80%) was recorded in 200 ppm NAA treatment followed by 500 ppm PBZ and 100 ppm NAA (0.78%). The mean minimum pectin content (0.61%) was observed in control treatment. However, the difference in control, 500 ppm ethrel and 500 ppm CCC treatments were found to be non-significant.

4.2.4.6 Reducing sugar :

The data on reducing sugar content of fruit as influenced by different plant growth regulator treatments are given in Table 4.21 and depicted in Fig. 4.21(a). The analysis of variance is given in Appendix – XXI.

The application of plant growth regulator treatments increased the reducing sugar content of fruit significantly as compared to control during the year 2002-03. However, in the year 2003-04 the effect was found to be non-significant. Even then, the pooled analysis of two year showed the mean maximum reducing sugar content (4.36%) was observed in 500 ppm ethrel treatment followed by 500 ppm PBZ (4.27%) treatment. The mean minimum reducing sugar content (3.96%) was recorded in control which was significantly lower than all the treatments.

4.2.4.7 Non-reducing sugar :

The data on non-reducing sugar content of fruit as affected by various plant growth regulator treatments are presented in Table 4.21 and depicted in Fig. 4.21(b). The analysis of variance is given in Appendix – XXI. The application of plant growth regulator treatments showed significantly pronounced effect on non-reducing sugar content of fruit over control during both the year of investigation i.e. 2002-03 and 2003-04.

The non-reducing sugar content of fruit was increased by application of different plant growth regulator treatments. The mean maximum non-reducing sugar content (3.01%) was obtained in 500 ppm ethrel treatment which was closely followed by 500 ppm PBZ (2.94%) and

250 ppm ethral (2.74%) treatments. The mean minimum non-reducing sugar content (2.10%) was obtained in control which was significantly lower than all the treatment.

4.2.4.8 Total sugar :

The data on total sugar content of fruits as affected by various plant growth regulator treatments used in present study are presented in Table 4.21 and depicted in Fig. 4.21(c). The analysis of variance is given in Appendix – XXI.

The application of plant growth regulator treatments significantly increased the total sugar content fruit over control during both the year of experiment i.e. 2002-03 and 2003-04. However, the pooled analysis of two year data showed mean maximum total sugar content (7.53%) in 500 ppm ethral treatment which was statistically at par with 500 ppm PBZ (7.37%) treatment. The mean minimum sugar content (6.17%) was observed in control and found statistically lower than all the treatments.

4.2.5 Yield

The data on yield kg/plant and tones/ha as affected by various plant growth regulator treatments are presented in Table 4.22 and depicted in Fig. 4.22(a) and (b). The analysis of the variance is given in Appendix – XXII. The application of different plant growth regulator treatments had significantly increase in yield (kg/plant and tones/ha) during both the year traditional studies (i.e. 2002-03 and 2003-04) under traditional system of planting.

The pooled analysis of two year data resulted mean maximum yield (63.83 kg/plant and 17.74 tonnes/ha) was recorded in 500 ppm PBZ treatment followed by 200 ppm NAA (58.78 kg/plant and 16.34 tonnes/ha) and 250 ppm PBZ (58.75 kg/plant and 16.33 tonnes/ha) treatments. However, the mean minimum yield (45.67 kg/plant and 12.69 tonnes/ha) was obtained in control which was found to be significantly lower than rest of the treatments used under present investigation.

6. SUMMARY

The field experiment entitled “Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava* L.) cv. ‘Sardar’ under high density and traditional system of planting” was conducted during two consecutive years of 2002-03 and 2003-04, at instructional farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The results obtained and discussed in the preceding chapters have been summarized below :

1. The application of plant growth regulators had significantly affected the shoot length in both the system of planting. The mean maximum increase in shoot length of 46.25 and 36.96 percent were recorded at 100 ppm NAA treatment in high density and traditional system of planting, respectively on 75 days after treatment. (Table 4.1 and 4.12).
2. The increase in shoot diameter was significantly influenced due to application of various plant growth regulator treatments. On 75 days after treatment the mean maximum increase in shoot diameter of 39.15 percent was recorded at 1000 ppm CCC treatment in high density planting system (Table 4.2) whereas, in traditional system of planting the mean maximum shoot diameter of 36.55 per cent was recorded at 500 ppm PBZ treatment (Table 4.13).
3. The number of leaves per growing shoot was significantly increased by various treatments of plant growth regulators over control in both the system of planting. However, on 75 days after treatment the mean maximum increase in number of leaves of 7.06 per growing shoot was observed at 200 ppm NAA treatment under high density planting system (Table 4.3). While, under traditional system of planting the mean maximum number of leaves of 6.91 per growing shoot was resulted due to 10 ppm triacontanol treatment (Table 4.14).
4. The effect of plant growth regulator treatment on days taken to initiation of flowering was significant over control in both the system of planting. The mean minimum days taken to initiation of flowering (27.50 days) was recorded in 1000 ppm CCC treatment followed by 500 ppm PBZ (27.67 days) treatment under high density planting system (Table 4.4) whereas, in traditional system of planting the mean minimum days taken to initiation of flowering [i.e. 29.0 days] was recorded in 500 ppm PBZ and 500 ppm ethrel treatments. (Table 4.15).
5. The number of flowers per shoot was significantly increased as a result of different plant growth regulator treatments over control under high density and traditional system of planting. The mean maximum numbers of flowers of 7.63 / shoot were recorded at 500

ppm ethrel under high density planting system. (Table 4.4) while, under traditional system of planting, the mean maximum number of flower of 7.77 / shoot were observed in 500 ppm PBZ treatment as compared to lowest (5.30 / shoot) in control (Table 4.15)

6. The fruit set was significantly increased by different treatment of plant growth regulators as compared to control under both the system of planting. The mean maximum fruit set of 71.78 and 71.17 percent were recorded at 500 ppm PBZ treatment under high density and traditional system of planting, respectively. Which were significantly higher than control (Table 4.5 and 4.16).
7. The fruit retention was increased significantly as a result of different plant growth regulator treatments over control in both the system of planting. The mean maximum fruit retention of 70.67 and 73.16 percent were observed in 500 ppm paclobutrazol treatment under high density and traditional system of planting, respectively. While the mean minimum fruit retention was recorded in control under both the system of planting (Table 4.5 and 4.16).
8. The application of different plant growth regulator treatments had significantly decreased the days taken to harvesting of fruits as compared to control under both the system of planting. The mean minimum days taken to harvesting (115.0 days) were recorded at 500 ppm ethrel treatment under high density planting system. (Table 4.4) where as, under traditional system of planting the mean minimum days taken to harvesting (115.33 days) were recorded in 500 ppm PBZ treatment which was closely followed by 500 ppm ethrel (115.50 days) treatment (Table 4.15).
9. The length of fruit was significantly increased due to application of various plant growth regulator treatments over control under high density and traditional system of planting. The mean maximum fruit length 7.40 and 6.67 cm. were obtained in 500 ppm PBZ treatment under high density and traditional system of planting, respectively (Table 4.5 and 4.16).
10. The diameter of fruit was significantly increased by application of different plant growth regulator treatments over control in both the system of planting. In high density planting system, the mean maximum fruit diameter 7.30 cm. was observed in 200 ppm NAA followed by 500 ppm PBZ treatment. However, under traditional system of planting the mean maximum fruit diameter 6.74 cm. was recorded in 500 ppm PBZ treatment (Table 4.6 and 4.17).
11. Organoleptic score /rating of guava fruits was significantly increased as a result of various plant growth regulator treatments over control under both the system of planting.

The mean maximum organoleptic score 8.87 and 8.67 out of 10.0 were recorded in 500 ppm ethrel treatment under high density and traditional system of planting, respectively (Table 4.6 and 4.17).

- 12.** The application of various plant growth regulator treatments significantly increased the weight of fruit over control under both the system of planting. The mean maximum fruit weight of 191.46 g. and 179.32 g. were recorded in 500 ppm paclobutrazol treatment under high density and traditional system of planting, respectively (Table 4.7 and 4.18).
- 13.** The volume of fruit significantly increased due to application of various plant growth regulator treatments as compared to control under both the system of planting. The mean maximum fruit volume of (188.16 cc and 172.45 cc) were recorded at 500 ppm PBZ treatment as compared to mean minimum of 129.31 cc and 118.56 cc in control under high density and traditional system of planting, respectively (Table 4.7 and 4.18).
- 14.** Plant growth regulator treatments had significantly decreased the specific gravity of fruit under high density and traditional system of planting over control. The mean minimum specific gravity of 1.018 g/cc was observed in 500 ppm PBZ treatment under high density planting system. (Table 4.7) while, under traditional system of planting the mean minimum specific gravity 1.038 g/cc was recorded in 250 ppm ethrel treatment (Table 4.18).
- 15.** The total soluble solids content of fruit significantly increased by the application of different plant growth regulator treatment as against control under both the system of planting. The mean maximum TSS content of fruit 15.66 and 15.35 percent were recorded in 500 ppm ethrel as compared to mean minimum total soluble solids content 12.15 and 11.75 percent in control under high density and traditional system of planting, respectively (Table 4.8 and 4.19).
- 16.** The application of plant growth regulator treatments in guava significantly reduced the acidity of fruit as compared to control under both high density and traditional system of planting. The mean minimum acidity of 0.390 and 0.375 percent were recorded in 500 ppm ethrel treatment under high density and traditional system of planting, respectively (Table 4.8 and 4.19).
- 17.** T.S.S. / Acid ratio of fruit was significantly increased due to application of various plant growth regulator treatments as compared to control under both the system of planting. The mean maximum TSS /Acid ratio of 40.40 and 40.97 were recorded at 500 ppm ethrel treatment under high density and traditional system of planting, respectively (Table 4.8 and 4.19).

- 18.** Ascorbic acid (vit.- C) content of guava fruit was significantly increased as a result of different plant growth regulator treatments over control under both the system of planting. Under high density planting system the mean maximum ascorbic acid content 210.82 mg/100g pulp was recorded in 500 ppm PBZ treatment. (Table 4.9) however, under traditional system of planting the mean maximum ascorbic acid content of 205.18 mg/100g pulp was observed in 200 ppm NAA treatment (Table 4.20).
- 19.** Pectin content of guava fruit was significantly increased due to application of plant growth regulator treatments under both the system of planting as compared to control. The mean maximum pectin content of 0.775 percent was recorded in 500 ppm PBZ (Table 4.9) under high density planting system. Where as, under traditional system of planting, the mean maximum pectin content 0.80 per cent was recorded in 200 ppm NAA followed by 500 ppm PBZ and 100 ppm NAA (0.78%) treatment (Table 4.20).
- 20.** Reducing sugar content of guava fruit was increased significantly due to application of various plant growth regulator treatments over control under both the system of planting. The mean maximum reducing sugar content of fruit 4.58 and 4.36 percent were recorded in 500 ppm ethrel treatment in both high density and traditional system of planting (Table 4.10 and 4.21).
- 21.** The non-reducing sugar content of guava fruit was significantly increased due to application of plant growth regulator treatments in both the system of planting over control. The mean maximum non-reducing sugar content of 3.11 and 3.01 per cent were recorded in 500 ppm ethrel treatment in both high density and traditional system of planting, respectively (Table 4.10 and 4.21).
- 22.** The application of different plant growth regulator treatments significantly increased the total sugar content of fruit over control under both the system of planting. The mean maximum total sugar content of 7.86 and 7.53 per cent were observed in 500 ppm ethrel treatment as compared to mean minimum 6.43 and 6.17 per cent in control under high density and traditional system of planting, respectively (Table 4.10 and 4.21).
- 23.** The yield of guava was significantly increased due to application of various plant growth regulator treatments in both the system of planting over control. The mean maximum yield of guava fruit 39.28 kg/plant (43.63 tones/ha.) and 63.83 kg/plant (17.74 tones/ha.) were recorded in 500 ppm PBZ treatment as compared to mean minimum in control under both high density and traditional system of planting, respectively (Table 4.11 and 4.22).

7. CONCLUSION

On the basis of results obtained in the present investigation entitled, “**Effect of plant growth regulators on growth, yield and quality of guava (*Psidium guajava L.*) cv. ‘Sardar’ under high density and traditional system of planting**” it may be concluded that the application of **500 ppm paclobutrazol** reduced / suppressed vegetative growth and resulted in to early flowering with maximum fruit set and retention as well as yield attributing characters such as size of fruit (length and diameter), weight and volume of fruit which ultimately increased the yield per plant and thereby per hectare in both high density and traditional system of planting.

This treatment also improved nutritional qualities of fruit such as increased in total soluble solids, reduction in acidity, improvement in ascorbic acid and pectin content of fruits. Further this treatment has also increased significantly the total sugar content of fruit including reducing and non-reducing sugars in both high density and traditional system of planting over control.

This treatment has also resulted an additional estimated income of Rs.72,476/ha with a 41.42 per cent increase in net profit over control under high density and Rs.24,140/ha with a 31.70 per cent increase in net profit over control under traditional system of planting, Table (5.1 and 5.2). Further it may be suggested that application of this treatment i.e. **500 ppm paclobutrazol** in guava is more beneficial under high density planting system rather than traditional system of planting.

Based on the above finding it could be recommended that ‘Sardar’ guava growers should apply **500 ppm paclobutrazol (cultar)** growth regulator before flowering.

Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha)

Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha)

Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha)

Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha) Estimated Yield (tonnes / ha)

Dr. R.K. Pathak Dr. R.K. Pathak Dr. R.K. Pathak Dr. R.K. Pathak

Dr. R.K. Pathak Dr. R.K. Pathak

DR. (Mrs) P. Gupta DR. (Mrs) P. Gupta DR. (Mrs) P. Gupta DR. (Mrs) P. Gupta

DR. (Mrs) P. Gupta DR. (Mrs) P. Gupta

LITRETURE CITED

- Agamy, S.Z. and Shaltout, A.D. (1989). Effect of some growth substances on fruit set and fruit characteristics of 'Banati Seedless' guava (*Psidium guajava* L.). *Ann. of Agril. Sci.*, (Cairo): 1175-1189.
- Agrawal, A.; Ram, S. and Garg, G.K. (1985). Endogenous cytokinins of mango (*Mangifera indica* L.) shoot tip and their significance in flowering. *Ind. J. Exp. Biol.*, **18** : 504-509.
- Albuquerque, J.A.S. De., Monco, M.A. and Do, C. (2000). Mango flowering induction. *Circular Tecnica da Embrapa Semi-Arido.*, **47** pp: 34.
- Albuquerque, T.C.S. De., Dechen, A.R., Camargo, E.C. and De, P.R. (2000). Growth retardants and nutritional characteristics on the grape cultivar 'Thompson seedless' and 'Italia'. *Scientia Agricola*, **57** (11) 45-53.
- Anbu, S.; Parthiban, S.; Rajangam, J. and Thangaraj, T. (2001). Induction of off season flowering in mango (*Mangifera indica* L.) using paclobutrazol. *South Ind. Hort.*, **49** (Special) 75-78.
- Anonymous (2003). *www. India agristate.com*.
- Ao. K.C. and Sarma, C.M. (1999). Effect of plant growth regulators on vegetative growth of pineapple. *Ind. Agric.*, **43**(1/2): 41 – 47.
- AOAC (1990). Official Methods of Analysis. *Association of Official Analytical Chemists*, AOAC, Benjamin Franklin Station, Washington D.C.
- Arulmozhiyan, R. (2000). Bioregulators in betelvine cv. 'Vellaikodi'. *Madras Agril. J.*, **87**(10/12): 730 – 732.
- Asrey, R.; Jain, R.K. and Singh R. (2003). Effect of plant growth regulators on growth and survival of strawberry runners under semi-arid region of Punjab. *Ind J. of Pl. Physiol.*, **8**(2): 196-198.
- Baghel, B.S.; Sharma, R.K. and Nair, P.K.R. (1989). Chemical constituents of mango fruits (*Mangifera indica* L.) as influence by foliar feeding of urea and NAA. *Guj. Agri. Uni. Res. J.*, **15**(1): 36-40.
- Bal, J.S.; Randhawa, J.S. and Singh, S.N. (1988). Effect of NAA on fruit characters and quality of ber cv. 'Umran'. *Harayana J. Hort. Sci.*, **17**(1-2): 20-23.

- Bal, J.S.; Singh, S.N.; Randhawa, J.S. and Jawanda, J.S. (1984). Effect of growth regulators on fruit drop, size and quality of *ber* (*Zizyphus mauritiana* Lamk.). *Ind. J. of Hort.*, **41**(3-4): 182-85.
- Banghel, B.S. and Tiwari, R. (2003). Individual and integrated effect of urea and NAA on flowering and fruiting of mango (*Mengifera indica* L.). *South Ind. Hort.*, **51**(1-6): 1-6.
- Bankar, G.J. and Prasad, R.N. (1993). Effect of GA and NAA on fruit set and quality of fruit in *ber* cv. "Gola". *Prog. Hort.*, **22**(1-4): 60-62.
- Banon, S.; Ochoa, J. and Gonzalez, A. (2001). Manipulation of oleander growth, development and foliage colour by paclobutrazol and ethephon. *Gartenbauwissenschaft*, **66**(3): 123-132.
- Barua, S.C. (1998). Productivity of 'Santa Rosa' plum trees in response to triacontanol. *J. of Interacademia.*, **2** (3): 124-129.
- Barua, S.C. and Das, M. (2000). Leaf and shoot growth in tea as affected by some growth substance. *Crop Res. (Hissar)*, **19**(3): 457-461.
- Bhattacharya, R.K. and Rao, V.N.M. (1994). Effect of growth regulators on duration of maturation, physical characters and chemical constituents of 'Co.2' papaya (*Carrica papaya* L.) fruit. *South Ind. Hort.*, **44**(1): 27-34
- Borowski, E.; Blamowski, Z.K; Michalek, W. (2000). Effect of Tomatex / Triacontanol / on chlorophyll fluorescence and tomato (*Licopersicon esculentum* mill) yield. *Acta physiologiae plantarum*, **22**(3): 271-274.
- Brahmchari, V.S.; Mandal, A.K.; Kumar, R.; Rani, R.; Kumar, R. and Rani, R. (1995). Effect of growth substance on fruit-set and physico-chemical characteristics of 'Sardar' guava (*Psidium guajava* L.). *Recent Hort.*, **2**(2): 127-131.
- Brahmchari, V.S.; Mandal, A.K.; Kumar, R.; Rani, R.; and Kumar, R. (1996). Effect of growth substances on flowering and fruiting characters of 'Sardar' guava (*Psidium guajava* L.). *Hortl. J.*, **9**(1): 1-7.
- Burondkar, M.M. and Gunjate, R.T. (1991). Effect of photosynthesis improving chemical on growth yield and quality characteristics of mango. Group workers meeting, *Res. Rep.* 18-20th September, 1991 APAU Rajendra Nagar, Hyderabad (A.P.) pp. 256-60.
- Chepman, K.R.; Saranath, J. and Paxton, B. (1979). Induction of early cropping of guava seedlings in a closely planted orchard using urea as a defoliant. *Aust. J. Exp. Agric. Anim. Husb.*, **19**: 382 – 384.

- Chen, W.S. (1985). Flower induction in mango (*Mangifera indica* L.) with plant growth substances. *Proz. Natl. Sci. Council Rep. of China*, **9**: 9-12.
- Choi, S. and Minsoon, H. (2001). Effect of foliar application of NAA on shoot growth fruit quality and return bloom, in 'Fuji' apple trees. *J. of Korean Soc. For Hort. Sci.*, **42**(2): 193-196.
- Choudhary, R.; Singh, U.P. and Sharma, R.K. (1997). Crop regulation in guava cv. 'L-49'. *Orissa J. of Hort.*, **25**(1): 10-13.
- Dubois, M.; Gilles. K.; Hamitton, J.K.; Robers, P.A. and Smith, F. (1951). A colorometric method for determination of sugar. *Nature*, **16**: 167.
- Erez, A. (1984). Dwarfing peaches by pruning and by paclobutrazol. *Acta Hort.*, **146**: 235-41.
- Farmahan, H.L. and Dhiman, M.L. (1998). Chemical thinning on fruit size, yield and quality in apricot (*Prunus americana* L.) cv. 'New Castle'. *Hort. J.*, **11**(1): 39-47.
- Ghora, Y.; Vasilakakis, M. and Stavroulakis, G. (2000). Effect of growth retardants (CCC, daminozide & Paclobutrazol) on growth and development of red raspberries cv. 'Autumn Bliss' cultivated under plastic green house condition in China-crete, Greece. *Acta Hort.*, **513**: 453- 458.
- Ghosh, S.N. (1998). Effect of foliar feeding of different commercial products of hormone and micro- nutrients on nut yield of cashew. *Environmental Ecology*, **16**(4): 962-963.
- Gour, G.S. (1996). Studies on crop regulation in guava. *Recent Hort.*, **3**(1): 21-23.
- Greenberg, J.; Izhak, K.; Izhak, G.; Nadav, V.; Benv, Y. and Yoram, K. (2000). Regulation of yield and increasing fruit size of 'or-1' mandarin by plant growth regulators. *Alon Hanotea*, **54**(7): 278-280.
- Hangastor, R. and Ries, S.K. (1978). Effect of triacontanol on plant cell cultures *in vitro*. *Pl. physiol.*, **61**: 855-57.
- Hassan, A.K. and Eissa, M.A. (1996). Effect of some chemical substances spray on fruiting and seed characteristics of guava. *Ann. of Agri. Sci., Moshtohor*, **34**(3): 1163-1175.
- Hussein, M.A.; Mostafa, F.M.A.; Abdel-Allah, A.Y. and Ahmed, N.M. (1998). Effect of paclobutrazol on vegetative growth and fruiting of 'Sultania' fig cultivar. *Assiut J. Agril. Sci.*, **29**(3): 189-200.

- Ilango, K. and Vijayalakshmi, S. (2002). Effect of some growth regulators and chemical on yield and quality attributes in tamarind (*Tamarindus indica* L.). *The Orissa J. Hort.*, **30**(1): 35-39.
- Jindal, K. and Chandel, J.S. (1996). Effect of triacontanol and paclobutrazol on fruit set, growth and quality of plum (*Prunus Salicina* L.). *Ind. J. Hort.*, **53**(4): 262-2638.
- Josan, J.S.; Sandhu, A.S. and Singh, R. (1998). Qualitative changes in the fruits of 'Baramasi' lemon as influenced by plant growth regulators. *J. of Res.*, Punjab Agri. Uni., **35**(¹/₂): 49-52.
- Konhar, T. and Arunmech (1988). Effect of growth regulators on flowering, fruit set and fruit retention in cashew (*Anacardium occidentale* L.). *Ind. Cashew J.*, **18**: 17-19.
- Kumar, A. R. and Sathiamoorthy, S. (2002). Effect of plant growth regulators on berry set and yield in black pepper var. "Panniyar – 1". *South Ind. Hort.*, **50** (4-6): 691-694.
- Kurian, R.M. and Iyer, C.P.A. (1993). Chemical regulation of tree size in mango (*Mangifera indica* L.) cv. "Alphonso". I. Effect of growth regulators on vegetative growth and tree vigour. *J. of Hort. Sci.*, **68**: 349-54.
- Lichev, V. (1999). Effect of the growth regulator cultar on flowering and ripening of the fruit in the 'Bigaro Berula' sweet cherry variety. *Rasteniev 'dni Nauk'* **36**(9): 495-499.
- Lichev, V.; Berova, M. and Zlatev, Z. (2001). Effect of cultar on the photosynthetic apparatus and growth of cherry tree. *Bulgarian J. of Agri. Sci.*, **7**(1): 29-33.
- Lin, S.; Huang, L.; Huang, Y. and Zhang, Q. (2000). Effect of pp 333 (cultar) on the growth and fruiting of 'Younai pulm'. *South China fruits*, **29**(1): 42-43.
- Mahajan, B.V.C. and Sharma, R.C. (1999). Effect of foliar application of growth regulators and calcium chloride on the size and quality of plum (*Prunns domestica* L.) cv. 'Satlaj purple'. *Hort. J.*, **12**(1): 73-76.
- Maibangra, S. and Ahmed, F. (2000). Effect of post flowering spray with NAA and GA₃ on ratoon pineapple. *Ann. of Agri. Res.*, **21**(1): 133-134.
- Mandal, B.K. and Kumar, R. (1989). Effect of photosynthesis improving chemical on vegetative growth, flowering and yield of guava. *Ind. J. of Hort.*, **46**(3): 449-52.
- Marini, R.P.; Byers, R.E. and Sowers, L.D. (1993). Repeated application of NAA control pre-harvest drop of 'Delicious apple'. *J. Hort. Sci.*, **68**: 247-53.

- Marizouk, H.M.M.; Mostafa, F.M.A. and Mohamed, Y.A.M. (1998). Effect of GA₃ and application of CCC on bud burst occurrence, vegetative growth and flower cluster development in 'Banaty' seedless cultivar (Thompson seedless) grown under Assiut condition. *Assiut J. of Agril. Sci.*, **29**(5): 115-127.
- Mohammed, S.; Lawrence, A.W. and Prendergast, N. (1984). Guava meadow orchard : Effect of ultra high density planting and growth regulators on growth, flowering and fruiting. *Trop. Agri. (Trinidad)*, **61**(4): 297-301.
- Murlidharan, R.; Saravanan, A. and Muthuvel, P. (2000). Influence of bio-stimulants on yield and quality of tomato (*Lycopersicon esculentum* mill). *Madras Agril. J.*, **87**(10/12): 625-628.
- Murti, G.S.R.; Upreti, K.K.; Kurian, R.M. and Reddy, Y.T.N. (2001). Paclobutrazol modifies tree vigour and flowering in mango cv. 'Alphonso'. *Ind. J. Pl. Physiol.*, **6**(4): 355-360.
- Nagalakshmi, U. and Gunasekaran (1989). Effect of triacontanol in increasing, vigour and yield of 'poovan' banana. *South Ind. Hort.*, **37**: 242-43.
- Nath, J.C. and Baruah, K. (1999). Regulation of flowering time, plant growth and yield in Assam lemon (*Citrus limon*) with the help of pruning and growth regulators. *Ind. J. of Agril. Sci.*, **69**(4): 292-294.
- Nieto-Angel, R. and Gil-Albert velarde, F. (2000). Chemical thinning of apple (*Malus pumilla* mill) fruits cv. 'Starkrimson' and 'Golden spur' in high density plantings. *ITEA production vegetal*, **96**(1): 27-41.
- Onaha, A.; Higa, M.; Naksone, F. and Ikemiya, H. (2001). Effect of ambient temperature and defoliation on flower bud induction with chemical in pineapple plants. *Japanese J. of Trop. Agri.*, **45**(1): 1-7.
- Panday, A.; Sharma, A.B.; Patel, M.P. and Panday, A. (1997). Effect of planting system cum high density on growth yield and quality of 'Sardar' guava (*Psidium guajava* L.). *Advances in Pl. Sci.*, **10**(2): 153-156.
- Panday, S.N. and Sinha, B.K. (2001). *Plant physiology*. Vikas Publishing House Pvt. Ltd., New Delhi. pp: 399-400.
- Pandey, D.K.; Pathak, R.A. and Pathak, R.K. (1989). Note on the foliar application of nutrients and plant growth regulators in cultivar 'Sardar' guava. II. Effect on ripening of fruits. *Ind. J. of Hort.*, **46**(1): 28-30.

- Pandey, V. (1999). Effect of NAA and GA₃ spray on fruit retention, growth, yield and quality of *ber* (*Zizyphus mauritiana* Lamk.) cv. 'Banarasi' and 'Karak'. *Orissa J. of Hort.*, **27**(1): 69-73.
- Panse, V.G. and Sukhatma, P.V. (1985). *Statistical methods for agricultural workers*. PP. 145-155. ICAR, New Delhi.
- Patil, H.K. and Talathi, J.M. (1999). Economic viability of paclobutrazol application in mango cv. 'Alphonso'. *South Ind. Hort.*, **47**(1-6): 145-146.
- Power, V.P.; Kathmale, D.K. and Patil, B.K. (2000). Effect of bio-regulators on yield and shelf-life of betelvine. *J. of Maharashtra Agri. Uni.*, **25**(3): 262-263.
- Purohit, C.B.S.; Singh, S.N. and Singh, N.P. (1977). Effect of certain plant growth substances in guava. *Haryana J. Hort. Sci.*, **6**(3-4): 117-119.
- Ramburn, N. (2001). Effect of girdling and growth retardants on flowering and fruiting of litchi in Mauritius. *Acta Hort.*, **558**: 229-232.
- Ranganna, S. (1977). Estimation of pectic substances as calcium pectate. *In hand book of analysis and quality control for fruits and vegetable products*. Tata McGraw Hill Publ. Co. Delhi. pp-31.
- Rao, M.M. and Nalawadi, U.G. (1968). Effect of naphthalene acetic acid on pedicel thickness of grapes. *Curr. Sci.*, **27**: 503-04.
- Salisbury, F.B. and Ross, C.W. (1992). *Plant physiology*. Pub. Wadsworth, Belmont, C.A.
- Sandhu, S.S.; Thind, S.S. and Bal, J.S. (1989). Effect of preharvest spray of ethephon on size, quality and ripening of *ber* (*Zizyphus mauritiana* Lamk.) cv. "Umran". *Ind. J. Hort.*, **46**: 23-27.
- Sao Jose, A.R. and Reboucas, T.N.H. (2000). Use of Paclobutrazol in Mango orchard in southwest region, Bahia state, Brazil. *Acta Hort.*, **509**: 713-715.
- Sargent, J.A. (1965). The penetration of growth regulators into leaves. *Ann. Pl. Physiol.*, **16**: 1-12.
- Sarkar, S.K.; Gautam, B.; Srihari, D. and Seethambaram, Y. (1998). Regulation of tree vigour in mango. *Ind. J. Hort.*, **55**(1): 37-41.
- Sawale, A.A.; Tayde, G.S.; Ghawade, S.M. and Dadmal, S.M. (2001). Effect of fruit thinning on quality of 'Nagpur' mandarin (*Citrus reticulata* Blanco.) under Akola condition. *Ind. J. of Agril. Res.*, **35**(2): 136-138.

- Shant, L.; Tiwari, J.P.; Misra, K.K. and Lal, S. (1996). Effect of plant spacing and pruning intensity on flowering and fruiting of guava. *Ann. of Agril. Res.*, **17**(1): 83-89.
- Sharma, T.R.; Nair, P.K. and Nema, M.K. (1990). Effect of foliar spray of urea, KNO₃ and NAA on fruiting behavior of mango cv. 'Langra'. *Orissa J. Hort.*, **18**(1-2): 42-47.
- Sherawat, S.K.; Daulta, B.S.; Dahiya, D.S. and Bhardwaj, R. (1998). Effect of growth retardants on growth, yield and fruit quality in grape (*Vitis vinifera* L.) cv. 'Thompson seedless'. *International J. of Trop. Agri.*, **16**(¹/₄): 179-184.
- Shikamany, S.D. and Reddy, N.N. (1989). Effects of growth retardants on growth, yield and quality in grape cv. 'Thompson seedless'. *Ind. J. Hort.*, **46**(1): 31-38.
- Singh, A.K.; Mughal, M.S. and Vachkoo, A.M. (2002). Effects of ethrel and naphthalene acetic acid on fruit quality and fruit drop of 'Royal Delicious' apple. *Ind. J. Hort.*, **59**(4): 355-358.
- Singh, A.R. and Singh, J.R. (1972). Effect of foliar application of nitrogen and plant growth regulators on the growth characters of mango. *Hort. Advances*, (9): 15-20.
- Singh, A.R.; Shukla, P.K. and Singh, K. (1989). Effect of B, Zn and NAA on the chemical composition and metabolites of *ber* (*Zizyphus mauritiana* Lamk.) fruit. *Harayana J. Hort. Sci.*, **18**(1-2): 23-28.
- Singh, B. and Rethy, P. (1995). Effect of certain micro nutrients and spray of plant growth regulators on the physical and bio-chemical parameters of 'Kagzi' lime fruits. *Prog. Hort.*, **24**(1-4): 216-219.
- Singh, D.K. (2000). Effect of paclobutrazol on yield and quality of different cultivars of *ber* (*Zizyphus mauritiana* Lamk.). *Ind. J. of Agril. Sci.*, **70**(1): 20-22.
- Singh, G. (1983). *Studies on the effect of growth regulators on fruit drop, size and quality of ber* (*Zizyphus mauritiana* Lamk.). M.Sc. thesis, PAU Ludhiana.
- Singh, G. and Reddy, Y.T.N. (1991). Effect of photosynthesis improving chemical on guava. *Group workers on meeting*. Res. Report 18-20th September, 1991, Rajendra Nagar, Hyderabad (A.P.), pp. 262-64.
- Singh, G.; Singh, A.K. and Verma, A. (2000). Economic evaluation of crop regulation treatment in guava (*Psidium guajava* L.). *Ind. J. of Agril. Sci.*, **70**(4): 226-230.
- Singh, H.K.; Singh, I.S. and Chauhan, K.S. (1979). Effect of pre-harvest application of ethephon on ripening and quality of guava cv. 'Sardar'. *Udyanika*, **2**: 117-120.

- Singh, I.S.; Singh, H.K. and Chauhan, K.S. (1980). Effect of high and low density plantation on yield and quality of guava under semi-arid conditions. *Haryana Agric. Uni. J. Res.*, **10**: 421-423.
- Singh, J.N.; Singh, D.K. and Chakarvarty, D. (1994). Effect of urea and NAA on fruit retention and physiochemical composition of mango (*Mangifera indica* L.) cv. 'Langra'. *The Orissa J. of Hort.*, **22**(1-2): 26-29.
- Singh, L. and Mukherjee, S. (2000). Effect of foliar application of urea and NAA on yield attributes of chilli. *Agri. Sci. Digest*, **20**(2): 116-117.
- Singh, O.P. and Phogat, K.P.S. (1984). Effect of growth regulators on fruit drop, size and quality of litchi cv. 'Calcuttia'. **24**(1-4): 83-87.
- Singh, P.; Dhatt, A.S. and Singh, S.N. (2000). Effect of fruit thinning on fruit drop, leaf fruit ratio, yield and return bloom in 'Kinnow' mandarin. *Ind. J. of Hort.*, **57**(1): 32-34.
- Singh, V. (1999). *Effect of Nitrogen, Agrispon and plant growth retardant on growth, flowering and yield of grape (Vitis Vinitera L.) cv. 'Thompson seedless'*. Ph.D. Thesis submitted to MPUAT, Udaipur.
- Singh, Z. (2000). Effect of paclobutrazol on tree vigour, flowering, fruit set and yield in mango. *Acta Hort.*, **525**: 459-462.
- Singh, Z. and Dhillon, B.S. (1992). Effect of paclobutrazol on floral malformation, yield and quality in guava (*Psidium guajava* L.). *Acta Hort.*, **296**: 51-53
- Snedecor, G.W. and Cochran, W.G. (1967). *Statistical methods*, 6th Ed. Oxford and IBH publishing Co., Calcutta.
- Somogyi, M. (1952). *J. of Biol. Chemistry*, **200**: 245.
- Stinchcombe, G.R.; Elizabeth, C.; William, R.R. and Arnold (1984). The effect of PP 333 and daminozide on the growth and yield of cidar apple trees. *J. Hort. Sci.*, **59**: 323-27.
- Subhadrabandhu, S.; Iamsub, K. and Katoka, I. (1999). Effect of paclobutrazol application on growth of mango tree and detection of residues in leaves and soil. *Japanese J. of Trop. Agri.*, **43**(4): 249-253.
- Sud, G. and Parmar, C. (1990). Effect of triacontanol on the fruit size and quality of apricot. *Ind. J. Hort.*, **47**: 177-79.
- Tao, J.; Shebg, B. and Zhang, F. (1998). Effect of chemical substances on shoot growth, fruit bearing, flower and fruit thinning of 'Fuji' apple trees. *Advances in Hort.*, **2**: 64-69.

- Tomar, A. (1984). Inhibition of flowering in mango by gibberellic acid. *Hort. Sci.*, **6**: 140-141.
- Turnbull, C.G.N.; Sinclair, E.R.; Anderson, K.L.; Nissen, R.J.; Shorter, A.J. and Lanham, T.E. (1999). Routes of ethephon uptake in pineapple (*Ananas comosus*) and reasons for failure of flowering induction. *J. of Plant growth regulators*, **18**(4): 145-152.
- Vijaylakshmi, D. and Srinivasan, P.S. (2000). Improving the quality attributes of 'off' year 'Alphonso' mango through chemical and growth regulators. *The Orissa J. of Hort.*, **28**(1): 27-31.
- Vijaylakshmi, D. and Srinivasan, P.S. (1998). Induction of flowering in off year mango cv. 'Alphonso' as influenced by chemical and growth regulators. *Ann. of Pl. Physiol.*, **12**(2): 93-97.
- Weaver, R.J. (1972). *Plant growth substance in agriculture*. W.H. Freeman and Company, San Francisco, **11**: 225-42.
- Webster, A.D. and Quinlan, J.D. (1984). Chemical control of tree growth of plum. *J. Hort. Sci.*, **59**: 367-75.
- Wittwer, S.H. (1978). *Phytohormones and chemical regulators in agriculture*. In : *phytohormone and related compound, - A comprehensive treatise II*, **13**: 599-615. Ed. Lenthann, D.S.; Goodwin, T. and Higgins, T. J.V. Pub. Elsevier, Holland.
- Yadav, P.K. (1998). Note on yield and quality parameters of guava as influenced by foliar application of nutrients and plant growth regulators. *Current Agri.*, **22**(¹/₂): 117-119.
- Yadav, R.B.R. and Singh, V.K. (1998). Long term effect of paclobutrazol on yield and quality of "Deshehari" mango (*Magnifera indica* L.). *Ind. J. Pl. Physiol.*, **3**(2): 166-167.
- Yadav, S.J.; Bhatia, S.K.; Godara, R.K. and Rana, G.S. (2001). Effect of growth regulators on the yield and quality of winter season guava cv. 'L-49'. *Haryana J. of Hort. Sci.*, **30**(1-2): 1-2.
- Yeshayahu, M.; Greenberg, J.; Beni, Y.; Cadmon, E. and Talmor, Z. (2001). Increasing fruit size of 'Myovaze' Satsuma mandarin by spray with plant growth regulators. *Alon Hanotea*, **55**(5): 205-207.
- Zhang, K.; Fuo, R. and Zhang, Z. (1988). Effect of plant growth regulators on fruit set in litchi. *J. Fujian Agri. College*, **17**: 54-61.