*Review Article*_____ *Chapter –19*

ACTION OF GROWTH RETARDANTS ON PAPAYA

Bhadarka Chandni R., Karmur N. N. And Kanzaria D. R.

Abstract

Papaya is a crop of tropical and subtropical region. Papaya is one of the evergreen plant in nature which have softwood and hollow stem. Papaya is wind susceptible plant. So, lodging in papaya plant is very common. Use of growth retardants in papaya fruit crop cultivation may be very beneficial in reducing heigh of papaya plant and prevents lodging in papaya. So, reduction in height of papaya benefit to papaya growers in papaya production. Some growth retardants play an important role in sex reversal and flowering behaviour of papaya plant. Reduction in the bearing height and internodal length is very effective in papaya by application of different plant growth regulators; specially growth retardants. Many researchers have worked on this aspect but still there is a need to find very specific retardant and a specific concentration. The finding of this research may help papaya growers to bring early flowering, male: female ratio, bearing height, intermodal length, yield and quality of papaya.

Department of Fruit Science, College of Horticulture, Junagadh Agricultural University, Junagadh – Gujarat (India)
E-mail: dilip_kanzaria@yahoo.com

Introduction

Papaya is a tropical as well as subtropical fruit crop. *Carica papaya* Linn is the botanical name of the papaya and it belongs to family Caricaceae, which have 48 species, only Carica papaya is the edible fruit (Chadha, 1992). It is originated from Mexico and tropical America (Heywood *et al.*, 2007).In 16th century it was introduced to India from Malacca. It is grown in all over the world and India is the leading producer of papaya. It is grown mainly in Brazil, Mexico, Nigeria, Indonesia, Peru, China etc. Papaya is one of the evergreen plants in nature which have softwood and hollow stem. It bears trifoliate leaves with long petioles. The height of papaya ranges up to 2.4 m and it can also withstand in low temperature and up to a height of 1500-2000 m. There are three sex forms of papaya monoecious, dioecious and hermaphrodite (Arrilia*et al.*, 1980). The fruit shape of female plant is short as compared to hermaphrodite plant. It has very fast growth it starts bearing after eight months of transplanting. It is highly profitable crop. Papaya is very refreshing and delicious fruit. Papaya is commonly recognised for having highly nutritive and medicinal value. It is highly valued for its digestive properties. Papaya has high amount of vitamin A and C. In 100 g pulp it contains 9.81 g carbohydrates, 0.61 % protein, 5.90 % sugars, 39 kcal energy, 61.8 mg of vitamin C, vitamin A is 1094 IU (Bhgawat*et al.*, 2011). The yellow pigment in papaya is due to caricaxanthin. Fruits contain valuable proteolytic enzyme, papain, which helps in digestion of protein rich foods. Because of its sweet taste it is freshly eaten and it has too much health benefits. Regular consumption of papaya can reduce the risk of heart disease, diabetes and cancer aiding in digestion.Ethrel is plant growth regulators with systemic properties. It penetrates into plant tissue and is translocated and progressively decomposed to ethylene, which positively affect the growth. Ethephone is a plant growth regulator used to promote fruit ripening, abscission, flower induction and other responses. Cycocel is a plant growth regulator mainly used for herbaceous crops. Cycocel treated plant are more compact with shorter internode, stronger stem and green leaves. Paclobutrazol is a plant growth regulator which affects the isoprenoid pathway and alter the level of plant hormones by inhibiting gibberellin synthesis and increasing cytokinins level. Paclobutrazol widely used to improve quality, synchronized fruit maturation, advance harvest maturity and promote flowering. When paclobutrazol is applied to the soil, it moves up through the roots in to shoots and due to anti-gibberellin properties, block the synthesis of flowering inhibitors and allow the flower promoting factor to work. The growth retardants are organic chemicals, which slow down cell division and expansion in tissues and regulate plant height physiologically without formative effects. This study is conducted to analyze the effects of growth retardants on dwarfing, flowering, yield and quality of papaya.

Related Studies

Chundavat and Gupta (1974) reported that growth retardants has dwarfing effect on vegetative growth and in number of fruits. Therefore, they conducted the experiment to study the response of different growth retardants on vegetative growth of phalsa plant during fruiting period. Maximum reduction in vegetative growth of more than 50 per cent was recorded at 4000 ppm B- nine as well cycocel.Jindal and Singh (1976) conducted an experiment on papaya. They treated papaya plant with Ethephone, TIBA and Morphactin

at 4th leaf stage. Ethephone treatment resulted in formation of first flower bud on main stem at lesser height (distance between first node and first flower bud as compare to control. They also noted that reduced height (52.5 cm), node number (27.75) and time taken for first flower bud emergence (83.25 days).Edgerton (1986) revealed that a pre bloom application following with two or three post bloom foliar applications of paclobutrazol (500 to 1000 ppm) on apple tree found effective in checking vegetative growth on mature apple tree. The treatment provided growth control of 40 to 60 % of the control. Hore*et al.* (1989) studied effect of chemicals on growth and yield of papaya by using MH, CCC, NAA, B-9, Ethrel GA_3 at various doses. They conclude that maximum number of leaves were obtained with ethrel 500 ppm.

Smeirate and Qrunflesh (1989) treated sixteen years old Lisbon lemon tree with various concentrations of paclobutrazol twice in the season at 500, 1000 and 2000 ppm. Result indicated the significant reduction in shoot and internode length and increased shoot diameter in the spring and summer. In the spring, paclobutrazol residues from 1000 and 2000 ppm treatments reduced shoot and internode length and increased shoot diameter. Paclobutrazol at 2000 ppm significantly reduced node numbers. Webster (1990) compared paclobutrazol in relation to growth and cropping of three plum cultivars (opal, Cambridge Gage and River's early prolific) by soil drench (1.6, 0.8 and 0.4 g *a.i.* tree) and foliar spray method (150 and 750 ppm mg/l). They showed that when paclobutrazol applied to the soil beanth to European plum tree prior to bud break in early spring significantly reduced mean extension shoot length.

Guha(1993) conducted an experiment to evaluate the effect of foliar application of cycocel 0.6 % and ethrel 0.1 % on five-year-old golden delicious apple tree. They observed that cycocel reduced the tree trunk diameter and tree volume. Guha (1993) conducted an experiment to evaluate the effect of foliar application of cycocel 0.6 % and ethrel 0.1 % on five-year-old golden delicious apple tree. They observed that cycocel reduced the tree trunk diameter and tree volume. Cycocel performed better in comparison to ethrel in all respect. Murti*et al.* (2001) conducted an experiment and observed that application of paclobutrazol 10 g/tree in mango resulted reduced tree height (21.20 %), tree volume (33.1 %) and mean shoot length (48.2 %). Supitchpong (2001) conducted an experiment at Rajamangla Institute of Technology Conference, PathumThani (Thailand). Study was designed to investigate the effect of paclobutrazol at different concentrations on growth and sex expression of papaya cv. Khagdam. The result showed that the length of petioles, the length and width of leaves emerged at 10-14 days through 60 days after received paclobutrazol at the concentrations of 800 and 1200 ppm were significantly reduced compared with those received at lower levels (400 and 0 ppm).

Kumar *et al.* (2005) framed an experiment to evaluate the effects of foliar spraying with cycocel (500, 1000 and 1500 ppm) and Paclobutrazol (500, 1000 and 1500 ppm) on growth, yield and fruit quality of peach cv. Paradelux growing high density orchard in chaubattia, Uttaranchal, India. They found that Paclobutrazol at 1500 ppm was the most effective in reducing the plant height, extension growth and shoot internode length. Cycocel 1500 ppm increased the fruit number and yield. However, total soluble solids and acidity were not affected by cycocel. Chanana and Gill (2007) studied on paclobutrazol effect on peach cv. early grand. They noted that minimum trunk growth, height and spread in paclobutrazol concentration 8 ml/tree.Ofosu-Anim and Nkonu (2003) conducted

an experiment on the effect of plant growth retardants on the growth of papaya. They observed that CCC 500, 1000, 2000 and 3000 ppm reduced plant height. CCC treatment did not significantly affect petiole length, leaf number, stem girth and chlorophyll content. CCC at 3000 ppm significantly increased stem girth.Singh *et al.* (2007) took an experiment on guava cv. Allahabad safeda. They noted the minimum tree height and canopy volume at ethephone 1000 ppm.

Shweta*et al.* (2017) took a present investigation of pruning (10-20cm of shoot length) and bio regulators (NAA 250ppm, Urea 15%, Ethrel 500ppm and Cycocel 50ppm) on vegetative growth parameters of guava variety Sardar. Result revealed that cycocel treated plants exhibited maximum reduction in stem girth (16.51cm) and E-W canopy spread (7.24m) 120 DAT. Kumra*et al.* (2018) conducted an experiment on strawberry. Strawberry crops grown with chlormequat chloride have shorter internodes but thicker, darker leaves. Ashok*et al.* (2021) conducted an experiment on Twenty-year-old mango tree cv. Dashehari planted in high density system (2.5 × 2.5 m). Soil application of paclobutrazol (1.0gm/canopy diameter/tree) resulted in a significant increase in flowering and slightly earlier flowering.

Jianchuan and Yuanmao (2021) conducted an experiment on Fuji apple. They applied four level of paclobutrazol (500, 1000, 1500 and 2000 mg/l) on autumn branches of five-year-old Fuji apple tree at fruit enlargement stage in 2018 and 2019. Result showed that paclobutrazol reduced leaf area, branch length, leaf number. Paclobutrazol had no significant effect on chlorophyll content obvious changes occurred when the concentration of paclobutrazol exceeded 150 mg/l including the inhibition of autumn branch growth. Kaur *et al.* (2022) growing grapevines under cover is an effective alternative to protect the berries from pre-monsoon rains in North Indian conditions. However, excessive vegetative growth under such conditions necessitates the use of growth retardants to enhance fruit quality and productivity. Chloromequat chloride (CCC) is one of the most widely used gibberellin biosynthesis inhibitors. The present research work was aimed at evaluating the effect of CCC (0, 250 ppm, 500 ppm, 750 ppm, and 1000ppm) on three grape cultivars 'Perlette', 'Flame Seedless', and 'Punjab Purple' grown under a polyhouse. Vines were sprayed with an aqueous solution of CCC at the five-leaf stage. Results revealed that exogenous application of CCC effectively retarded the cane and internodal length with a simultaneous increase in cane thickness. Among the cultivars, the maximum reduction in cane length (28.1%) and increase in cane diameter (22%) was recorded in 'Perlette'.

Effect on Flowering:

Ghose and Sen (1975) carried out an experiment on Papaya by using nitrogen, NAA, CCC, MH, GA_3 and animal sex hormone stilbosteroldipropionate and testosterone chemicals which were applied at $5^{th}$and 6^{th} leaf stage and second after 3 to 4 months later. They concluded that CCC promotes femaleness in treated plants. Aravind and Jaiswal (1984) carried out an experiment on sex reversal and fruit formation on male plants of papaya by ethrel and chlorflurenol at Banaras Hindu University, Varanasi. They used various concentration of ethrel (240, 480, 960 ppm). They observed that male plant of papaya was induced to bear female flowers and yield a good fruit crop by application of ethrel at various concentrations. During conversion of male flowers into female flowers, some intersexual flowers with transition were observed. The female flowers produced by

ethrel were similar to the control female flowers. Maximum number of female flower (35) and minimum number of male flower (5) observed at 960 ppm ethrel concentration.Edgerton (1986) revealed that a pre boom application following with two or three post bloom foliar applications of paclobutrazol (500 to 1000 ppm) on apple tree found effective in checking vegetative growth and enhanced flowering on mature apple tree.

Brahmachari*et al.* (1996) reported that CCC 500 ppm induced early flowering and highest number of flowers in sardar guava.Narayan *et al.* (2013) conducted an experiment on growth regulators on flowering and fruit growth of guava at Assam Agricultural University. The maximum number of flowers (16) per shoot, highest fruit set per cent (93.13) and maximum number of fruits per shoot at harvest (6.2) were found with 1000 ppm CCC. Supitchpong (2001) conducted an experiment at Rajamangla Institute of Technology Conference, PathumThani (Thailand). Study was designed to investigate the effect of paclobutrazol at different concentrations on growth and sex expression of papaya cv. Khagdam. The result showed that 800 ppm paclobutrazol concentration tented to reduce male flowers, but increased hermaphrodite flowers.Vijayalakshmi and Srinivasan (2002) conduct an experiment on mango cultivar Alphonso at Coimbatore. They observed that 10 ml/tree paclobutrazol produce longest panicle (31.57 cm), number of branches per panicle (13), total number of flowers per panicle (620), number of hermaphrodite flowers (189.67) number of male flowers (425) and hermaphrodite flowers (39.59 %). Bagel *et al.* (2004) studied on Paclobutrazol effect on Mango cv. Langra at Jabalpur Madhya Pradesh. He noted that maximum number of flowering shoots/m^2 (30.32) and percentage of flowering shoots (96.15) in 5 g/tree paclobutrazol concentration. The earliest panicle emergence (162 days) was observed on trees applied with paclobutrazol at 3.75 and 5.00 g *a.i.*/ha.Pusdekar and Pusdekar (2009) studied the effect of plant growth regulators on flowering and fruit quality in papaya cv. CO 2 at Punjab Rao DeshmukhKrishiVidhyapeeth. The experimental findings revealed that ethrel induced early flowering. Syamal*et al.* (2010) conducted an experiment on influence of plant growth substances on vegetative growth, flowering, fruiting and fruit quality of papaya at Banaras Hindu University, Varanasi. They noted that ethrel (200 and 300 ppm) proved to be the best particularly in the reduction of number of days taken for sex differentiation and promotion of femaleness.Subrata*et al.* (2019) conducted an experiment to find out the effect of CCC, KNO_3, $ZnSO_4$ and MAP on flowering and yield of wood apple at Bidhan Chandra KrishiViswavidyalaya. The experiment was laid out in a Randomized Block Design (RBD) with five treatments viz., control, CCC, KNO_3, $ZnSO_4$, MAP each treatment has four replications. The plants treated with CCC at 0.2 % recorded early flowering (26thFebruary, 2017) and the maximum intensity of flower (7th March, 2017). Ashok *et al.* (2021) conducted an experiment on Twenty-year-old mango tree cv. Dashehari planted in high density system (2.5 × 2.5 m). Paclobutrazol (1.0gm/canopy diameter/tree) was applied to soil by spraying the basin. It was found that the third and fourth flushes of the treated trees were significantly shorter than that of the control, and their intermodal lengths were remarkably reduced. The canopy sizes of the treated trees were significantly reduced in height. Firoz (2021) conducted field trial at ICAR-IIHR, Bengaluru to assess the effect of different chemicals on flower induction, fruiting and yield parameters in tissue cultured plant propagules of pomegranate cv. Bhagwa during 2016-17. The foliar application of cycocel 1500 ppm gave a significantly

increased number of hermaphrodite flowers (287.84) and intermediate flowers (254.14) per plant, reduced number of male flowers (219.70) produced per plant.

Effect on Yield and Quality

Garg and Singh (1976) sprayed ethrel (125, 250, 500 and 1000 ppm) and cycocel (250, 500, 750 and 1000 ppm) on cape gooseberry reduced stem height and induced early flowering whereas ethrel delayed it. Both cycocel and ethrel increased yield of fruits, although highest yields were obtained with ethrel 500 ppm and cycocel 1000 ppm. Cycocel exhibited no effect on ripening rate whereas ethrel enhanced ripening by 10 days. Schmidt (1978) concluded that Golden delicious and carola apple tree treated with one or two applications of ethephone at 150 and 300 ppm showed no check to vegetative growth but 300 ppm induced bud formation. Flower bud production on heavily cropping trees was stimulated by two applications at 150 ppm ethephone which resulted in a reduction in annual variability of cropping but the overall yield for four years of period increase slightly. Shikhamany and Reddy (1989) observed that 3000 ppm CCC at 15 leaf stage in grape was found to be highly effective in increasing yield/vine. Brahmachari*et al*. (1995) reported that application of ethrel at 25 or 50 ppm in guava enhanced fruit set percentage, weight, quality of fruits while reduced number and weight of seeds there by increased pulp/seed ratio. Singh et al. (2000) conducted an experiment on Guava cv. Sardar. They observed that highest yield (103.98 kg/tree) during the winter season by spraying ethephone 1800 ppm.

Brahmachari*et al.* (1995) studied effect of foliar spray of CCC in six 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.Brahmachari*et al.* (1996) reported that CCC 500 ppm induced the highest number of fruit set, retention and yield in sardar guava. Sarkar et al. (1998) conducted a field experiment in kesar mango at Andhra Pradesh. They found that application of CCC 750 to 3000 ppm increased yield significantly over control in mango by improving the number of fruits/tree and weight of fruit.Sherawat*et al.* (1998) conducted an experiment on grape and sprayed the paclobutrazol. Spray of paclobutrazol increased the berry set, bunch size, yield and quality in respect to TSS and Acidity of fruit. Nath and Baruah (1999) conducted an experiment on regulation of flowering time, plant growth and yield on Asam lemon with the help of pruning and growth regulators. They reported that spray of 3000 ppm CCC in lemon gave the highest yield. 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.Albuquerque *et al.* (2000) found that application of 1500 ppm CCC increased the number of fruiting buds in grape.

Ghora*et al.* (2000) conducted an experiment on effect of growth retardants (CCC, daminozide and paclobutrazol) on growth and development under plastic greenhouse condition on red raspberries cv. 'Autumn Bliss'. They found that application of 500 ppm CCC enhanced anthesis and fruit ripening by about 10 days. Onaha*et al.* (2001) found higher percentage of flower bud induction in pineapple by application of ethephon.

Kumar *et al.* (2005) carried out experiment to evaluate the effects of foliar spraying with cycocel (500, 1000 and 1500 ppm) and Paclobutrazol (500, 1000 and 1500 ppm) on growth, yield and fruit quality of peach cv. Paradelux growing high density

orchard in chaubattia, Uttaranchal, India. They found that 1500 ppm cycocel increased the fruit number and yield. However, total soluble solids and acidity were not affected by cycocel. Haropinder and Bal (2006) framed an experiment at Punjab Agricultural University, Ludhiana to ascertain the effect of pruning (10 and 20 cm) and growth regulators (paclobutrazol and ethephon 500 and 1000 ppm) on physico-chemical characters of guava cv. Allahabad Safeda during rainy season planted with four different spacings (6 x 2, 6 x 3, 6 x 4 and 6 x 5 m). Paclobutrazol 1000 ppm resulted maximum fruit size and fruit weight. Haropinder and Bal (2006) framed an experiment at Punjab Agricultural University, Ludhiana to ascertain the effect of pruning (10 and 20 cm) and growth regulators (paclobutrazol and ethephon 500 and 1000 ppm) on physico-chemical characters of guava cv. Allahabad Sufeda during rainy season planted with four different spacings (6 x 2, 6 x 3, 6 x 4 and 6 x 5 m). Minimum seed number per fruit, maximum palatability rating and TSS were observed with ethephon 1000 ppm.

Singh and Ranganath (2006) conducted experiment on mango cv. Banganpalli. They applied paclobutrazol 5 ml/tree (twice) before bud break and noted that maximum number of fruits per panicle at harvesting stage and number of fruits/trees. Baskaran and Sathiamurthy (2008) conducted an experiment on effect of growth retardants on quality of papaya cv. CO 2 at Tamilnadu Agricultural University. They noted higher level of total sugar (12.25 %) at 500 ppm paclobutrazol concentration and highest level of titrable acidity (0.716 %) at 1000 ppm. Ascorbic acid content also increased with higher concentration of paclobutrazol. Baskaran and Sathiamurthy (2008) carried out an experiment on effects of growth retardants on quality of papaya at Tamilnadu Agricultural University. They noted that ethrel at 150 ppm had recorded the highest TSS:acid ratio of 84.94. Pusdekar and Pusdekar (2009) studied the effect of plant growth regulators on flowering and fruit quality in papaya cv. CO 2 at Punjab Rao DeshmukhKrishiVidhyapeeth. The experimental findings revealed that CCC 1000 and 1500 ppm recorded pronounced effect regarding fruit thickness. CCC 500 ppm recorded maximum ascorbic content in fruit. Pusdekar and Pusdekar (2009) studied the effect of plant growth regulators on flowering and fruit quality in papaya cv. CO 2 at Punjab Rao DeshmukhKrishiVidhyapeeth. Acidity content in fruit was significantly lower in ethrel (0.12-0.15 %).Auxcilia*et al.* (2010) conducted an experiment on effect of paclobutrazol on yield and quality of fruit and latex of papaya var. CO 2. The study conducted with paclobutrazol at 2 levels viz, 25 and 50 mg/plant. Study revealed that paclobutrazol increased total carotenoids, TSS, sugar, ascorbic acid and sugar acid ratio. Response being linear with increasing concentration.

Jain and Dashora (2010) conducted an experiment on guava cv. Sardar. They noted that maximum fruit length (6.67 cm), fruit diameter (6.74 cm), fruit weight (179.32 g), fruit volume (172.45 cc) and thereby maximum yield (6.83 kg/tree) at 500 ppm paclobutrazol concentration. Yadav (2012) conducted an experiment on cape gooseberry. He applied various doses of paclobutrazol (12.5, 25, 50 and 100 ppm) and ethephone (100, 200, 400 and 800 ppm) on flowering, fruit character and quality of cape gooseberry. Result indicated that the ethephon 800 ppm delayed flowering over prolonged duration of fruit set and early ripening by 30.25, 2.5 and 10.13 days, respectively over control. Ethephone 400 ppm found more effective than 800 ppm in respect of fruit weight and quality constitute. Syamal*et al.* (2010) took an experiment on influence of plant growth substances on vegetative growth, flowering, fruiting and fruit quality of papaya at Banaras

Hindu University, Varanasi. They applied gibberellic acid GA_3 100 and 150 ppm, TIBA (2, 3, 5- Triodo Benzoic Acid) 100 and 150 ppm and ethrel 200 and 300 ppm. They found ethrel 200 and 300 ppm was best for improving fruit quality. Kumar *et al.* (2012) framed an experiment on strawberry production in subtropical region. They used different concentrations of CCC (250, 500 and 750 ppm), GA (30, 60 and 90 ppm) and NAA (20, 30 and 40 ppm). Highest value for fruit yield (330.7 g/plant and 20.15 t/ha.Martinez-Fuentes *et al.* (2013) conducted an experiment on citrus. Results indicate that effect is fruit-load dependant. In 'Salustiana' and 'Navelina' sweet oranges, 'Hernandina' Clementine mandarin, and 'Afourer' and 'Moncada' hybrids, flowering intensity significantly increased the following spring for medium-to-low fruit-load trees treated with either 1–10 g PBZ/tree applied to the soil or 15 g/tree sprayed on the canopy. PBZ significantly increased the percentage of sprouted buds and leafless floral shoots (both single-flowered shoots and inflorescences) and reduced the number of vegetative shoots. By contrast, heavy fruit load trees receiving the same amount of PBZ in the same season or at floral bud differentiation period scarcely flowered. In conclusion, the effectiveness of PBZ in promoting flowering in *Citrus* depends on the fruit load since the tree showed a cultivar-dependant threshold value above which PBZ is unable to promote flowering.Narayan *et al.* (2013) conducts an experiment on growth regulators on flowering and fruit growth of guava at Assam Agricultural university. The highest fruit set per cent (93.13) and maximum number of fruits per shoot at harvest (6.2) were found with 1000 ppm CCC.

Reddy *et al*. (2013) studied on effect of paclobutrazol on fruit quality attributes in mango cv. Totapuri. They observed that paclobutrazol treated tree increase 23.4 % total sugar, 29.6 % reducing sugar, 77.4 % glucose and 27.8 % sucrose content was recorded over fruits from the untreated tree.Kacha*et al.* (2014) investigated on performance of various growth regulators on yield and quality of phalsa at the Fruit Research Station, Junagadh Agricultural University, Junagadh. The experiment was laid out in Randomized Block Design (RBD) with three replications. There were ten treatments comprised of NAA (100, 150 and 200 ppm), GA3 (50, 100 and 150 ppm), Ethrel (500, 750 and 1000 ppm) and control (water spray). The quality of fruits in terms of TSS (25.23 per cent), reducing sugar (2.01 per cent) and total sugar (5.74 per cent) were significantly higher in treatment with Ethrel 1000 ppm followed by Ethrel 750 ppm. Further, Ethrel 1000 ppm also significantly reduced the span of harvesting (9.76 days) and number of pickings (3.57) followed by Ethrel 750 ppm. Hazarika*et al.* (2016) conducted an experiment to investigate the response of plant growth regulators on the growth, yield and quality of tissue cultured papaya cv. Red Lady at Mizoram University. They observed that quality parameters, such as TSS (16.91 ºBrix), total sugar (10.17 %), reducing sugar (7.58 %) and non-reducing sugar (2.59 %) of fruits, 400 ppm of ethrel, exhibited significantly maximum value and lowest titrable acidity (0.128 %). Maximum pulp thickness (2.95 cm) was recorded with 1000 ppm CCC.

Patil*et al.* (2016) undertaken study for three years during 2010-11 to 2012-13 on 15 years old mango trees of Pairi variety at Main Garden, Department of Horticulture, Dr.PanjabraoDeshmukhKrishiVidyapeeth, Akola for induction of regular bahar in mango. The treatments were consisted of Cycocel - 2500, 5000, 7500 ppm, KNO_3 -0.5 %, 1.0 %, 1.5 %, Ethrel- 200 ppm, 300 ppm and Control and replicated trice. Chemicals of different concentrations were sprayed in the first fortnight of October (one month before the fruit

bud differentiation). Cycocel -2500 ppm sprayed in the month of October recorded maximum fruit set per cent (2.11 %) and highest yield in terms of number (585.11 numbers) and weight (160.71 kg / tree). Ashok *et al.* (2019) studied on effect of paclobutrazol on mango cv. Dashehari, Langra, Chausa and Fazari. They observed that paclobutrazol at 1.0 g resulted in higher edible portion, lower stone pulp ratio and peel pulp ratio, longer shelf life, high TSS, increased vitamin C, Lower titrable acidity, higher dry matter, higher reducing and non-reducing sugar and total sugar content as compared lower doses 0.5 g with control plants.

Subrata*et al.* (2019) conducted an experiment to find out the effect of CCC, KNO_3, $ZnSO_4$ and MAP on flowering and yield of wood apple at Bidhan Chandra KrishiViswavidyalaya. The experiment was laid out in a Randomized Block Design (RBD) with five treatments viz., Control, CCC, KNO_3, $ZnSO_4$, MAP each treatment has four replications. The plants treated with CCC at 0.2 % recorded early flowering (26th February, 2017), the maximum intensity of flower (7th March, 2017), fruit set (10th March, 2017), highest fruit set (3.00 %), retention (68.75 %), number of fruits per plant (80.25), yield per plant (16.04 kg.) as well as yield per hectare (6.42 ton)), specific gravity (1.17), total sugar (9.14 %) was recorded with the use of cycocel 500 ppm.Firoz (2021) conducted field trial at ICAR-IIHR, Bengaluru to assess the effect of different chemicals on flower induction, fruiting and yield parameters in tissue cultured plant propagules of pomegranate cv. Bhagwa during 2016-17. The foliar application of cycocel 1500 ppm gave a significantly increased the percentage of fruit setting (86.10 %) and number of fruits (156.66) per plant. Thus, fruit yield (54.53) kg/plant and (21.81) tones/ha, fruit weight (348.32 g), fruit length (8.53 cm) and fruit volume (333.93 ml) increased significantly. Gilson *et al.* (2021)carried out an experiment on Tahiti acid lime and ponkan mandarin. Result revealed that Tahiti acid lime plants treated with paclobutrazol obtained average 77.24 fruits m^2/plant canopy, while control had 16.08 fruits m^2/plant canopy. In ponkan mandarin, treated plants obtained 87.49 fruits m^2/plant canopy while control hand 30.94 fruits m^2/plant canopy. Paclobutrazol applied to Tahiti acid lime and ponkan mandarin plants allowed significant increase in amounts of fruits. Pragya*et al.* (2021) taken an experiment on effect of various bio regulators and girdling on winter flushing, flowering intensity, fruit yield and quality of litchi cv, china. The experimental result revealed that highest TSS (22.60 °Brix) and TSS:acid ratio (66.97) of the fruits were recorded in paclobutrazol.Roshan*et al.* (2022) conducted an experiment on twenty years old trees of sapota cv. Cricket Ball with foliar spray of different concentrations of plant growth regulators applied at 50 per cent flowering and pea stage of fruit growth at Horticulture instructional Farm, Department of Fruit Science College of Agriculture, Indira Gandhi KrishiVishwavidyalaya, Raipur (C.G.). The experiment was laid out in Randomized Block Design having twenty-five treatments, which replicates thrice. It was observed that application of ethrel @ 1000 ppm at 50 per cent flowering + pea stage (T_{18}) significantly reduced the days to first harvest (211.50), days to last harvest (231.66) and length of harvest period (20.16) as compared to rest of the other treatments tested under the present investigation.

Conclusion

Papaya is a crop of tropical and subtropical region. Papaya is one of the evergreen plant in nature which have softwood and hollow stem. Papaya is wind susceptible plant. So, lodging in papaya plant is very common. Use of growth retardants in papaya fruit crop cultivation very beneficial in reducing height of papaya plant and prevents lodging in papaya. So, reduction in height of papaya benefit to papaya growers in papaya production. Some growth retardants play an important role in sex reversal and flowering behaviour of papaya plant. Reduction in the bearing height and internodal length is very effective in papaya by application of different plant growth regulators; specially, growth retardants. Hence, growth retardants play an important role in increasing number of flowers, early flowering, reduce plant height, reducedinternodal length, increase yield and quality of fruit.

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