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Kommana Pavani1
Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Subhrajyoti Mishra
PhD Research Scholar, College of Horticulture, JAU, Junagadh, Gujarat, India

Divya Vani Vaka
PhD Research Scholar, Department of Fruit Science, College of Horticulture, Dr. Y.S.R. Horticultural University, Andhra Pradesh, India

Lhingneivah Chongloi
PhD Research Scholar, Department of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Dilip Kumar Dash
Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Correspondence
Kommana Pavani1
Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

A review on combined effect of pruning and foliar application of chemicals on flowering and fruiting of acid lime (*Citrus aurantifolia* Swingle)

Kommana Pavani1, Subhrajyoti Mishra, Divya Vani Vaka, Lhingneivah Chongloi and Dilip Kumar Dash

Abstract
In most citrus species, heavy fruit drop and occasional low fruit set are serious problems. The continued fruit drop at various stages of fruit development results in considerable reduction in yield and leads to low profit to citrus growers. So, the use of various growth regulators and chemicals to control fruit drop in citrus fruits which improve the productivity as well as quality of the produce is suggested. Therefore, this problem attracted the attention of large number of researchers to find some positive control measures on vegetative growth behaviour, reproductive biology, yield parameters and quality attributes through the use of plant growth regulators (PGRs) and other chemicals along with pruning. In this review we have tried to compile the previous research and findings in a precise way.

Keywords: Pruning, Foliar, Flowering and Fruiting, Acid Lime, *Citrus aurantifolia* Swingle

Introduction
Citrus species is grown throughout the world in tropical and subtropical climate, where there is suitable soil and sufficient moisture available to sustain the trees. The finest quality table citrus fruits are grown in non humid irrigated subtropical areas. It is grown in more than 100 countries under tropical, subtropical and Mediterranean climatic conditions. India ranks fifth among major lime and lemon producing countries in the world. It is considered to be one of the most remunerative fruit crops that have a lasting niche in the international trade and world finance.

Acid lime (Citrus aurantifolia Swingle) belongs to the family Rutaceae. It is native of India and South Eastern China (Hume, 1957) [28]. In India, citrus fruits are cultivated in an area of 985 thousand hectare with a production of 11419 thousand million tonnes (NHB, 2016) [57]. Among citrus species lime occupies 248 thousand hectare in area and 2364 thousand metric tonnes in production. It is largely cultivated in Andhra Pradesh, Maharashtra, Tamil Nadu, Gujarat, Rajasthan and Bihar. Odisha accounts for 2.4% and ranked 9th to the National production of citrus fruits. Mayurbhanj, Keonjhar, Koraput, Ganjam, Gajapati, Dhenkanal are the major lime growing districts in Odisha (Ministry of Agriculture, 2015) [48]. In this chapter an investigation has done to focus the findings of past workers which are directly or indirectly related to pruning and foliar application of chemicals in Acid Lime (Citrus aurantifolia Swingle).

Growth dynamics, flowering behaviour, fruit set and fruit retention Growth in citrus tree is sympodial, thus all shoots are determinate and a negative correlation exists between shoot length and flowering (Lord and Eckard, 1987) [43]. Thus the shorter the stem the more flower it bears. Hittalmani et al. (1977) [27] observed four growth flushes per year in both in Kagzi lime and Tahiti lime during January, May, June and October. The major flushes were seen in January, May and June. The vegetative growth occurs in distinct flushes which are cyclic with period of active growth alternating with a period of quiescence. The time of initiation of three flushes, the magnitude of growth and productivity vary with number of factors such as environment, species, varieties and age of the tree (Hittalmani, 1977 and Soni and Randhawa, 1975) [27, 71]. The number of spring shoots is determined by internal factors connected with previous crop load and the extent of vegetative flushes Prior to bud sprouting in spring (Goldschmidt and Monselise, 1972 and Mishra et al., 2018) **[24, 51]**. Soni and Randhawa, (1975) **[71]** observed significant variation in extension of growth, leaf size, number of leaves

and leaf area per shoot in different flushes of lemon. Flowering in acid lime started only after the third week of March, which was normal flowering season of lime under Chitwan condition in Nepal (Tripathi and Dhakal, 2005) [75]. Albrigo and Sauco (2004) [4] studied flower bud induction of sweet orange trees and observed that buds at apical positions produced more flowers than buds located far from the apex. Shoot age had a significant effect on floral development. For equal number of shoots, more flowers developed on buds from summer shoots in comparison with spring shoots. Therefore, when comparing buds from summer and spring flushes, buds from previous summer are more easily induced than spring buds. Hasta bahar (October-November flowering and fruit matures in February-April) is considered as best fruiting season because of more economic returns over rest seasons. However, more yield of acid lime crop produced during July- August coupled with poor quality fruits which fetches low price. This bahar can be achieved through water stress and hormones (Mahalle *et al*., 2010 and Debaje *et al*., 2010) [44, 14]. Nir *et al*. (1972) [58] reported that increased intensity of flowering due to stress showed that flower bud differentiation occurred during moisture stress and that generative buds formed did not undergo flower development till water was supplied.

Rajput and Haribabu, (1985) [61] studied the fruit set was low under high temperatures at the time of bloom. Extreme hot and dry weather during the month of May-June causes shedding of half developed fruits (June drop). Low humidity developed good colour and external appearance and high humidity developed thin skinned and small size fruits but high in quality. Ghosh *et al*. (2012) [20] stated that application of NAA @ 15ppm reduced the fruit drop percentage and gave the maximum number of fruits per tree compared to control in Sweet orange. They also reported the maximum fruit weight with 2, 4-D @ 10ppm compared to control in Sweet orange.

Effect of Pruning on growth and yield of citrus

The main reason for pruning fruit trees is to foster a high quality yield (Lewis and McCarty, 1973) [40]. Other beneficial effects of pruning are control of tree form and size, improvement of canopy function, chlorophyll synthesis, photosynthate production, improvement of fruit size, ease of spraying and picking and improvement of pack out (Mishra and Dash, 2018a) [49]. Pruning should increase in the illumination needed for photomorphogenic effects (Cohen *et al*, 1988) [10]. Cook (1992) [11] reported that an invigorating effect was observed after pruning Clementines. Summer pruning treatment produces the highest income and provided a beneficial cultural practice. Pruning performed on growing or dormant stems removed apical dominance, releases buds from correlative inhibition, and changes tree form and construction (Mika, 1986) [47]. Krajewki and Rabe (1995) [38] investigated bud age on sprouting and flower bearing Clementine mandarin trees and demonstrated the potential of hand-pruning to manipulate sprouting and return bloom. The proportion of axillary buds sprouting and the number of spring shoots produced in axillary site decreases with decreasing bud age. Heading of stems significantly increased percentage of leaf axils that sprouted in spring.

Singh *et al*. (2001) [69] conducted an experiment on guava in which pruning is done in different months. Compared to pruning in February and March, pruning from April through June, enhanced number of shoots and flowering percentage. Penetration of photosynthetic photon flux was generally greater in canopies of pruned trees than in un-pruned trees during May and June. In all the years, the quantum of fruit yield harvestable during December and January increased significantly by May pruning. Ingale *et al*. (2005) [30] studied on severity of pruning, light pruning (15-25 cm), medium pruning (25-45 cm), heavy pruning (45-75 cm) and control (no pruning) of acid lime. Results revealed that maximum fruit yield (902 fruit/ tree/ year) with superior quality fruits were recorded in medium pruning.

Ahmad *et al*. (2006) [3] reported that mature bearing trees of "Kinnow" mandarin were pruned like heavy pruning, light pruning and no-pruning. The maximum yield in term of number of fruits per plant (610 in 1st year and 841 in 2nd year) was noted in heavy pruning. Attractive fruit colour and better quality fruit with the maximum fruit weight (248.5 g) and the maximum juice percentage (46.39) were also observed in the same treatment. Heavy pruning appeared to be the best pruning method to be obtained the maximum yield, quality and orange red colour of Kinnow fruits. A study was conducted on effect of pruning and growth regulators on physicochemical characters of guava during rainy season planted at different spacing. The results indicated that the maximum fruit size, palatability rating, TSS and vitamin C were noted in wider spacing (6 m x 5 m). The maximum fruit weight and the minimum seed number per fruit were recorded in 6 m x 3 m and 6 m x 5m spacing respectively. The minimum seed number per fruit and the maximum palatability rating, TSS were observed with etheophon @1000 ppm. Paclobutrazol @1000ppm resulted maximum fruit size and fruit weight, whereas the maximum vitamin C was found in control in guava fruits. Physical characters like fruit weight was improved at 20 cm level of pruning, whereas, fruit quality (chemical characters) were noted better at 10 cm level of pruning. (Singh and Bal, 2006) [70]. Sarita *et al*. (2012) [65] observed that pruning thrice a year to 50 per cent of shoot length in cv. Sardar guava resulted in maximum yield of summer, winter season and total yield per ha (34.88 t/ha and 37.24 t/ha) also maximum gross return has obtained.

Effect of Growth regulators on fruit growth and development

Growth regulators like GA3, 2, 4-D etc significantly affects the fruit growth and development. Chundawat and Randhawa (1972) [9] reported the reduction in fruit drop up to
88.62 per cent with 2, 4-D @ 10 to 20ppm in mandarins when applied at pea stage withlanoline paste and gibberellic acid treatments increased the fruit size significantly over 2, 4-D. Dilute spray of 2,4-D and GA3 @ 10 to 20ppm after 5 to 9 weeks of bloom reduced fruit drop in all seasons in case of navel oranges in Florida. 2, 4-D at 10ppm has been found to increase fruit retention up to 50 to76 per cent whereas the control has the fruit retention 2.4 per cent only (Lima and Davies, 1984) [41].

Go Guey (1990) [23] reported increase in the number of fruits 186 per tree with the application of paclobutrazol @ 5ml per tree particularly in pruned mango trees of cv. Valencia, when compared to control (132). In Pant lemon-1 2, 4-D at 5 to 20ppm and GA3 at 20ppm when applied 14 days before full bloom, at full bloom and again 14 days later, reduced fruitdrop. They also reported the highest fruit size 56.32g by the application of NAA 5 or 20ppm and GA3 at 10 or 40ppm (Babu and Lavania, 1985) [8]. According to Thukral *et al*. (1996) [74] Pant lemon fruits matured fastest 165 Days when they were sprayed with GA3 + BA@ 25ppm each compared to control 183 Days. According to Anandbahadur *et al*. (2002) [6] Foliar application of NAA @ 400ppm significantly

increased the fruit fresh weight 48.56g as compared to control 36.64 g in Kagzi lime. Shinde *et al*. (2006) [67] reported the Paclobutrazol applied 3ml and 5ml per meter canopy at 90 days before bud break (15th August) and 120 days before bud break (15th July), significantly increased flowering 68.48-80.60 per cent and increased the fruit number (216) and yield from 92.82 to 117.82 per tree compared to control118 and 30.03 per tree respectively. Kacha *et al*. (2012) [34] observed significantly highest number of fruits 60.74 and yield 1.71 per plant by the application of NAA @ 150ppm compared to control 26.34and 850 g per tree respectively in Phalsa. Narayanlal *et al*. (2013) [55] observed that fruit drop was significantly reduced (38.80%) and increased the maximum fruit size in terms of length 9.8 cm, diameter 10.23 cm, weight 182 g, volume 178.33 cc and yield37.13 per tree with GA3 50ppm compared to control 69.53% and 5.3cm, 6.17 cm, 80.33 g 78.67 cc and 12.16 per tree respectively in guava cv. Allahabad Safeda. They also reported the maximum number of flowers (16) per shoot, fruit set (93.13%) and number of fruits per shoot (6.20) at harvest by the application of CCC 1000ppm compared to control 6.2, 52.43% and 3.74 respectively.

Rizwan *et al*. (2014) [63] reported that the maximum number of fruits per branch (13.58), fruit weight (149.92 g) and yield (62 per tree) were obtained when the plants were treated with foliar application of GA3 10ppm in sweet orange. Mohsen (2014) [52] stated that the application of gibberellic acid and potassium alone or in combination increases in number fruits per cluster and faster fruit growth in addition to increasing fruit number, fruit firmness,weight and yield. Elkhishen (2015)[16] reported that application of KNO3 6 per cent + Ethrel 800ppm gave the significantly highest number of secondary branches per panicle (33.7), average number of flowering shoots per tree (0.96), total number of panicles per tree (314.3), fruit retention percentage (6.2%) and yield (47.2/tree) compared to control in mango cv. Zebda. They also reported the maximum number of fruits per tree (88.3) with Paclobutrazol 5 g + Ethrel 400ppm compared to control (24.3) in mango. Pradeep *et al*. (2016) [60] revealed that the fruits treated with GA3 20ppm retained higher fruit weight (128.6 g), and better juice recovery (57.75%) in mandarin.

Effect of Urea Spray on Vegetative growth

Gilani (1989) observed in Kinnow plants the maximum growth was obtained with NPK + Planofix with respect to tree girth, height and stem width parameters, when the N was applied in 2 doses (February and April) whereas P and K were applied in February. Urea had little effect on per cent fruit set but it increased leaf N and shoot growth, especially at the higher rate on Kinnow (Lodhi and Rashid, 1980) [42]. El Otmani *et al*. (2002) [18] and Dubey *et al*., (2003) [15] suggested foliar applied urea represents an effective and most efficient method as a source of nitrogen in sustainable citrus production system encouraging vegetative growth. According to Rathore and Chandra (2003) [62] soil and foliar application of nitrogen alone and in combination with zinc sulphate (0.5%) increased vegetative growth of acid lime trees with respect to plant height, spread (north to south and east to west) and stem girth. The maximum increase in these parameters was recorded in the treatment of 300 g soil application of nitrogen in two split doses (in the month of July, and March) and foliar spray of 1.5 per cent urea and 0.5 per cent ZnSO4 twice in the month of September and March. Holding irrigation for a period of 45 days with spraying urea twice was efficient in increasing the ammonium concentrations in lime leaves and produced the highest number of flower per branch and fruit set per branch in lime trees (Egyptian Lime, *C. aurantifolia*) (EL-Tanany *et al*., 2011) [19].

Al-Obeed *et al*. (2017) [5] studied the effect of urea, zinc (Zn) and boron (B) foliar sprays either alone or in combinations on fruit yield and quality of “Kinnow” mandarin. A significant increase in tree yield and an enhancement in fruit physical characteristics (fruit weight, pulp, juice, volume, length and diameter) and chemical characteristics (soluble solid content, acidity, pH, total sugars and ascorbic acid) were noticed in treated plants. Heerendra *et al*. (2017) [26] laid down an experiment on Kinnow trees which comprises treatments of 1 per cent urea, 0.4 per cent ZnSO4, 20ppm 2, 4-D and their combination. The results revealed thatthe foliar application of 1 per cent urea, 0.4 per cent zinc sulphate and 2, 4-D- 20ppm in combination resulted in highest tree growth in comparison to control. It was found that leaf nutrient contents (N, P, K, Ca, Mg and Cu) were also recorded maximum in treated trees. The application of urea + ZnSO4+ 2, 4-D caused maximum increment in tree height, trunk girth, tree volume and shoot extension growth. This increase in growth characters might be due to the fact that nitrogen is an integral part of chlorophyll which primarily absorbs light energy needed for photosynthesis, so it may be attributed to higher photosynthetic efficiency.

Effect of Urea on Flowering, Fruit Set and Fruit Drop

Flowering and fruit set is the most important character determining the final production of crop. In case of acid lime there are two types of flower. Though season have a greater impact on the type of flowers as reported by Mishra and Dash (2018b) [50] but the percentage pf hermaphrodite flower can be enhanced by application of various growth regulators, chemicals in combination with pruning. Syamal *et al*. (2008) [72] found that the spray of 4 percent urea andpercent zinc sulfate in February-March increased minimum duration of flowering and maximum number of flowers in Kagzi lime trees. The minimum fruit drop and maximum fruit retention were also recorded in the same treatment. The percentage of fruit-let thinning increased with the increase in urea concentration. Trees sprayed with 6.0 per cent urea recorded the highest percentage of fruit- let thinning (88.27%) after 30 days of application in Kinnow. (Kaur *et al*., 2005) [36]. Sweet orange cv. Mosambi received Nitrogen at 400, 800 or 1200 g/tree applied in split doses (January, March and June) through the soil or foliage application as one percent urea. Foliar application of N at the highest rate gave the best results with regard to fruit set (71.7-73.8%), reduction in pre harvest fruit drop (9.07-9.81%) and yields (352-396 fruits/tree), compared to control (Govind and Prasad, 1982) [25].

Effect of Urea on fruit yield and quality

Urea sprained at 0.5 per cent concentration increased height, girth, length of roots and number of leaves in grafted walnut plants. Though maximum juice and total soluble solids obtained in fruits of the trees sprayed with 1.0 and 0.8 per cent urea and zinc sulphate, respectively still ascorbic acid content in Kinnow fruits, decreased with increasing concentration of urea and zinc sulphate (Malik *et al*., 2000) [45]. Maximum yield (525 fruits/ tree), juice content (53.57%) and minimum peel thickness were recorded with the application of 1900 g urea + 2730 g superphosphate per tree in Kinnow. Maximum TSS/acid ratio (15.99) was recorded with medium dose of Nitrogen (Monga *et al*., 2004) [53].

Meena *et al*. (2005) [46] hasconducted an experiment on Guava cv. Sardar under HDP with 4 levels of Urea (0, 2.0, 2.5 and 3.0% as foliar), Zinc sulphate (0, 0.5, 1.0, and 1.5% as foliar) each and their combinations. Double foliar sprays of urea at 3 per cent gave the maximum fruit length (5.744 cm), width (5.520 cm), Weight (124.470 g), number of fruits per plant (314.67), fruits per plant (37.80), pulp: seed ratio (46.045) and TSS (11.125%). Abd El-Rhman and Shadia (2012) [1] investigate the effects of foliar sprays on jujube by urea (1 and 2%), ZnSO4 (0.4 and 0.6%) and their combination and observed better result on increased yield, fruit physical characteristics (fruit weight, fruit length, fruit width, fruit volume and fruit diameter) and fruit chemical characteristics (TSS, acidity and Total sugars).

Effect of GA3 spray

GA3 (5 mg/l) sprayed to the entire tree at petal-fall enhanced initial set in the 'Navelate' sweet orange (Agusti *et al*., 1982) [2]. Spraying of 4 gallons of a solution of GA3 (18 g a.i./acre) and organo-silicone surfactant (Silwet, 0.05%) per tree on sour orange (*Citrus aurantium* L.) rootstock had greater juice yield when harvested than fruit from Non sprayed trees (Davis *et al*., 1997) [12]. Pre-harvest as well as postharvest factors affect yields, composition and quality of citrus fruits. Foliar sprays of urea (1 and 1.6%) at flower initiation and differentiation stage was suggested to increase flowering and GA3 (10ppm) applied during flowering to increase fruit set. Free amino acid content of fruit was more in GA3 treatment while ascorbic acid content in urea (1.6%), GA3 and KNO3 treated fruits El-Otmani *et al*. (2004) [17]. Maximum number of fruits per tree (5422), average weight of individual fruit (20.91 g) and fruit yield per tree (111.05 Kg) was obtained with the application of borax (0.4%) before panicle emergence. Interaction treatment {i.e. Borax 0.4% (before panicle emergence) x GA3 20ppm (after completion of fruit set)} produces highest fruit yield (123.10) per plant. GA3 (20ppm) and ZnSO4 (0.4%) were found most effective treatments to increase reducing sugar and total sugars (Kumar and Verma, 2004) [39]. All PGR treatments, except CPPU significantly increased the diameter of the fruit. GA3 significantly increased total yield in terms of number of fruit per tree (Thomas and Lovatt, 2004) [73].

Combined effect of NAA and GA3

Ghosh *et al*. (2009 [21] studied the effect of plant growth regulators in yield and fruit quality in pomegranate cv. Ruby with seven treatments and three growth regulators, viz., NAA (25, 50ppm); GA3 (10, 20ppm); 2,4-D (5, 10ppm) and control (water spray) were sprayed three times. Results revealed that application of NAA at 25ppm gave the significantly high fruit set (44.3%) and fruit retention (44.1%) which resulted in the highest fruit yield (7.8 Kg/plant). Gill and Bal (2009) [22] suggested that ber fruits when sprayed with NAA (20,30 and 40ppm), KNO3 (0.5, 1.0 and 1.5%) and ZnS04 (0.3, 0.4 and 0.5%) it was observed that fruit size, fruit weight, TSS, vitamin C was enhanced by NAA 30ppm with improved fruit quality. Shabana (2009 [66] studied the effect of pruning with application of NAA (0, 25, 50 or 100ppm) in the on year, on inducing flowering and yield in the off year season of mango cv. Zebda. Trees were subjected to the pruning treatments (light, moderate and severe pruning). The results revealed that highest number of new flushes per shoot was achieved with severe pruning and spraying NAA at 100ppm. Moderate pruning with NAA at 100ppm was the most effective treatment for increasing length of new flushes and recorded the highest number of leaves per flush. Severe pruning and application of NAA at 50ppm gave the maximum number of panicles per shoot. Severe pruning with NAA 50ppm was most effective for increasing number of fruit per tree. Moderate pruning and NAA at 50ppm proved to be the most effective treatment for improving yield of Zebda mango trees in the off-year season.

Along Kachave and Bhosle (2009) [35] experimented on Kagzi lime with two growth regulators, NAA (100ppm and 200ppm) and GA3 (50ppm) singly and in combination with micronutrients at flowering and pea size fruit stage. Results revealed that NAA 200ppm + micronutrients mixture 1per cent spray was the best treatment for increasing TSS, acidity, ascorbic acid, reducing sugar of fruit and chlorophyll-b content of leaves. Debaje *et al*. (2011) [13] suggested that effect of foliar sprays of plant regulators viz., GA3, NAA and nutrients like urea and KNO3 singly or in combination on qualitative parameters of hasta bahar acid lime. Results revealed that two foliar spray of KNO3 2 per cent, GA3 100ppm and NAA 300ppm increased fruit set, fruit weight, fruit volume and improved fruit quality. Maximum juice percentage, TSS and ascorbic acid content was obtained whereas acidity and peel percentage was reduced resulting into better quality fruit. Mahalle *et al*. (2010) [44] studied the quality and yield of hasta bahar flowering in acid lime with various treatments viz., T1-GA3 50ppm, T2- Cycocel 1000ppm, T3- KNO3 (1%), T4-Thiourea (1%), T5- Salicylic acid 100ppm, T6- ascorbic acid 50ppm and T7- control. Results revealed that the yield (number of fruits per tree and weight of fruits per tree) and various fruit quality characters (juice, TSS, acidity, ascorbic acid, peel and pomace percentage) were improved with the application of Cycocel 1000ppm at an interval of one month before initiation of flowering). Jagtap *et al*. (2013) [31] investigated the effect of foliar application of plant growth regulators and micronutrients on yield and quality of acid lime cv. Kagzi (*Citrus aurantifolia*). The result revealed GA3 50 mg/l significantly increase yieldattributing characters like fruit diameter (4.54 cm), fruit weight (47.40 g) and fruit yield per tree (46.38). Treatment NAA 200 mg/l significantly increase the number of fruits per tree (1020.33). Quality attributing characters like total soluble solid (9.58˚Brix.) and ascorbic acid content (30.41 mg/100g pulp) were significantly increased while number of seeds per fruit and acidity were significantly decreased under treatment GA3 50 mg/l. Nafea *et al*. (2014) [54] reported that olive cv. Ashrasie foliar application GA3 (100, 125 mg/l) in combination with NAA (50, 100 mg/l) gave maximum value of most physical characteristics fruit set, yield and oil of olive trees cv.Ashrasie. Jain *et al*. (2015) [32] studied the effects and economic feasibility of plant growth regulators on yield of Nagpur mandarin (*Citrus reticulate* Blanco). The yield attributing characters like weight, volume and diameter of fruit with number of sacs per fruit were maximum with the spray of 100ppm GA3, which was closely followed by 2, 4-D 30ppm. Indrani *et al*. (2017) [29] recorded the maximum yield (12.27 t/ha) with the application GA3 at 20mg/l in Ber.

Fruit Quality Parameters

Saleem *et al*. (2008) recorded maximum fruit juice (51.4%) in fruit treated with GA3@ 20ppm as compared to control 40.77% and TSS 11.48˚ Brix and in control 9.22˚ Brix in Blood Red sweet orange. Patil *et al*. (2011) [59] stated that the maximum juice (55.28%), TSS (10.28˚Brix) and minimum acidity (0.62%) were recorded by the application of 2,4-D @

10ppm + Carbendazim 1 per cent. Exogenous application of PGRs (2, 4-D, GA3, NAA) significantly increased 'Kinnow' mandarin fruit set percentage and increase the average fruit yield/plant. Fruit quality (juice, TSS, acidity and fruit size) were also improved by the application of PGRs which, at lower concentrations enhanced fruit parameters more efficiently than higher concentrations (Azher *et al*., 2011) [7]. Application of PGRs significantly increases in the juice percentage (53.29%) in 10 mg/l GA3, followed by 20 mg/l GA3. Nawaz *et al*. (2008) [56] stated that the maximum juice percentage (51.66%), TSS (11.73˚Brix) and ascorbic acid content (45.30 mg/100 g) were recorded under GA3@ 100ppm and minimum juice percentage (43.74%), TSS (9.67˚Brix) and ascorbic acid (36.93 mg/100 g) under control. They also recorded the highest acidity (1.04%) by the application of NAA 15ppm and minimum acidity (0.78%) was found in 2, 4-D 10ppm in Kinnow mandarin. Application of kinetin 30ppm gave maximum juice percentage (50.67%) and rind thickness (4.50 mm) as compared to control 42.63% and 3.80 mm respectively in Kinnow mandarin. They also reported the maximum TSS with the application of Kinetin 10ppm whereas, minimum TSS (8.60˚Brix) and acidity (0.78%) in control and maximum acidity (0.96%) with BA 20ppm Khalid *et al*. (2012) [37]. The maximum juice content (52.59%) was recorded with 100 ppm GA3 which was followed by 30 ppm 2, 4-D. The application of GA3 150ppm in phalsa significantly increased (57.78%) of juice content (Jain *et al*., 2014) [33] Pradeep *et al*. (2016) [60] observed the juice recovery percentage was significantly higher (57.75%) in fruits treated GA3 at 20ppm than non-treated fruits (45.06%). The improvement in fruit quality parameters (TSS, ascorbic acid, sugars and acidity) was highest with the application of GA3 (50 ppm) + Thiourea (0.1%). The maximum ascorbic acid content (670 mg/100 g fruit pulp) was noted with the application of GA3 50 ppm + Thiourea 0.1 per cent (Singh and Singh, 2015) [68].

Conclusion

As Citrus, provides wider opportunity to study many questions related to flowering and fruiting due to its unusual reproductive biology, we can manipulate all tree specific traits controlling and influencing flowering, fruit development and quality which will definitely help to generate a proper strategy required for a substantial production and availability of citrus fruit in a global and competitive world in respect of economic status as well as nutrition and health prospective.

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