Review Article

# New generation PGR's in fruit production




## ABSTRACT

Plant hormones are small molecules derived from various metabolic pathways, which are present at a very low concentration and act either locally, at or near the site of synthesis, or in distant tissues. Plant ~~hormones includes~~hormone includes the new generation PGRs like brassinoids, jasmonic acid, salicylic acid, polyamines, triacontanol, 1-MCP and prohexadione – Ca. We often refers to five classical plant hormones; which were identified in the early to mid 20th century. The activities of new class PGRs depend on their concentration and environmental factors affecting their absorption and plant's physiological state. PGRs have the ability to effect to effect cell division, cell structure, cell expansion, cell function and mediate environmental stress even at low concentrations. Direct application of roots, leaf, flowers, buds and shoots has been shown to enhance resistance to biotic and abiotic stress. Products of PGRs are generally employed throughout viticulture, floriculture, agriculture and horticulture to increase crop yield in sub-optimal soil and harsh environmental conditions. New class of plant hormones which play important roles in various physiological processes including seed development and germination, flower sex expression, fruit development, improvement of quality and quality of produce and resistance to various biotic and abiotic stresses.


Comment [W1]: Rewrite the sentence

**Key Words:**PGRs, Brassinosteroids, Jasmonic acid, Salicylic acid, Polyamines, Ttriacontanol, 1-MCP and Prohexadione – Ca.

## INTRODUCTION

Plant Growth Regulators (PGR's) are those compounds which are responsible for upregulation or downregulation of factors responsible for growth, development and other physiological processes. PGR's can be natural or synthetic. PGR modifies or controls one or more specific physiological processes. Site and action of different PGR's are different in different plants. PGR's can be grouped in 2 categories based on how long they are being used significantly in horticulture sector. There are some PGR's which are well harnessed and used widely by farmers. These includes Auxins, Gibberellins, Cytokinins, Ethylene and Abscisic acid. Apart from these there are PGRs whose efficacy and efficiency are known to us but due to technological gap they are not yet been harnessed at grass root level. These include Brassinosteroids (BR), Jasmonate (JA) and Salicylic acid (SA). Brassinosteroids are class of plant polyhydroxysteroids which is present in almost every part of plants inc. Brassicaceae. Application of BR exhibited a decline fruit abortion and fruit fall. Increase pollen tube growth and fertilization. BR prevented premature abscission of fruit. BRs also regulate the activity of defense related enzymes which could develop strong defense mechanism against different microorganisms. It was reported found that altering the level of endogenous BRs, promotes fruit quality (Li *et.al*., 2010; Lieselotte *et.al.*, 2014). Organic compound found in jasmine flower (*J. grandiflorum*) and chemical formula $C_{12}H_{18}O_3$. Can be biosynthesized from linolenic acid by the octadecanoid pathway. JA enhances embryo formation, determination and development of flowers and overall fruit set (Hink *et.al.*, 2008). JA and methyl jasmonate protect plants from herbivores and pest by synthesis of enzymes such as proteinase inhibitors and chitinases and volatile aldehydes and oxoacids. JA and MJa improves the total antioxidants and phenol content (Kohli *et.al.*, 2018). Salicylic acid ($C_7H_6O_3$) is a monohydroxy benzoic acid (type of phenolic acid and betahydroxy acid). Derived from the metabolism of salicin. SA have influence on photosynthesis, ion uptake, membrane permeability, enzyme activities, flowering and growth and development of plants.

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**Comment [W3]:** Add two more recent citations

**Comment [W4]:** Expand



**What are Plant Growth Regulators (PGR's)?**

1. PGRs are those compounds which are responsible for up-regulation or down-regulation of factors responsible for growth, development and other physiological processes.
2. PGR's can be natural or synthetic.
3. PGR modifies or controls one or more specific physiological processes.
4. Site and action of different PGR's are different in different plants.

**Classical Plant growth regulators**

A. Plant Growth Promoter's

1. Auxin
2. Gibberellins
3. Cytokinin

B. Plant Growth Inhibitor's

1. Abscisic Acid
2. Ethylene

**Table 1: New generation PGRs : Their site of synthesis, precursor and primary functions**

| Hormones | Site of synthesis | Precursor | Primary functions |
|---|---|---|---|
| Brs | ✓ Pollen<br>✓ Seeds and young tissues | Castasterone | ✓ Promotes stem elongation, cell division<br>✓ Inhibit root formation and growth<br>✓ Induces xylem differentiation<br>✓ Stimulates seed germination |
| JA | ✓ All living tissues<br>✓ Young developing fruits<br>✓ Cotyledons of germinated seeds | 12-oxophytodienoic acid (OPDA) | ✓ Enhancement of meristem formation<br>✓ Induces plant defense responses<br>✓ Increases production of secondary metabolites with a role in plant defenses<br>✓ Promote regeneration of shoots and roots |
| SA | ✓ Leaves | Phenylalanine | ✓ Signal in thermogenic plants<br>✓ Signaling horm6ne in plant resistance to pathogens<br>✓ Signaling molecule for flowering |
| PAs | ✓ All living plant cells especially actively dividing ones | Ornithine (Put), agmatine (Spd) and arginine (Spm) | ✓ Enhance cell division<br>✓ Delays leaf senescence<br>✓ May help in regulate flowering<br>✓ Inhiits ripening and senescence |

**Source: Edward F. Durner (Principles of Horticultural Physiology)**

**New generation PGR's**

1. Brassinosteroids (BR),

2. Jasmonate (JA)
3. Salicylic acid (SA)
4. Polyamines
5. Triacontanol (TRIA)
6. 1-MCP (1-Mthylcyclopropene)
7. Prohexadione – Ca

## 1. Brassinosteroids (BR)

These compounds were first isolated from rape (*Brassica napus* L) pollens in 1979 by M.D. Grove and his coworkers identified the active component as brassinolide (BL) (Rao*et al*., 2002), and subsequently in other plants (Sasse, 1997). Brassinosteroids collectively refer to naturally occurring 5α-cholestane steroids that elicit growth stimulation in nano or micro-molar concentrations (Clouse &Sasse, 1998; Choe, 2004).

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Due to BRs' growth regulator activity, this class of phytohormones is involved in a range of developmental processes, including cell division and elongation, vascular differentiation, reproductive development and the modulation of gene expression (Bajguz, 2007).

The main responsible for BR-mediated responses are BZR1 (BRASSINAZOLE RESISTANT 1) and BES1 (BRI1-EMS SUPPRESSOR 1), also named BZR2, the two major BR signaling pathway transcription factors, which regulate a range of genes involved in different physiological processes, such as developmental responses, protein metabolism, cellular transport and signaling, cell wall biosynthesis, chromatin and cytoskeleton components, environmental responses, and hormone responses (Sun*et al*., 2010).

BR prevented premature abscission of fruit. BRs also regulate the activity of defence related enzymes which could develop strong defence mechanism against different microorganisms. It was reported found that altering the level of endogenous BRs, promotes fruit quality (Li *et. al*., 2010; Lieselotte *et. al*., 2014).

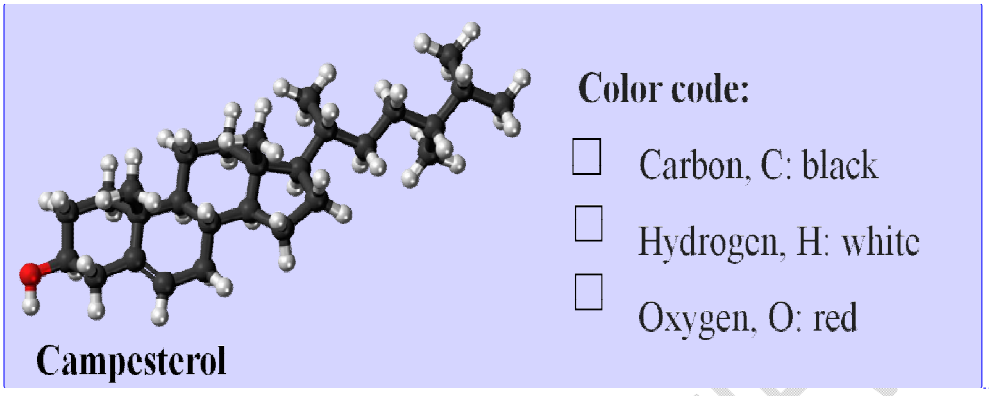


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**Figure 1: Precurssor of Brassinoids (Campesterol)**



**Functions:**

- Promotion of cell expansion and cell elongation
- Role in cell division and cell wall regeneration
- Promotion of vascular differentiation
- Pollen elongation for pollen tube formation
- Protect plants from chilling and drought stress

**Effect ofBrassinosteroids in fruit crops:**

Research conducted to study the effects of brassinosteroids on different developmental stages of various plant species have focused primarily on determining their impacts on seed germination and alleviating stress effects on development (Vardhini & Rao, 1997; Leubner-Metzger, 2001; Anuradha & Rao, 2003).

Exogenous application of brassinolide was effective in influencing all physico-chemical properties of litchi fruits. Among the treatments of brassinolide studied, brassinolide at 1 mg $l^{-1}$ (two-time application i.e., 15 daysbefore and after anthesis) was identified to be superior based on suitable morphological characteristics, biochemical compositions which can be selected for further improvement with minimum fruit cracking and can be promoted for cultivation (Ghose *et al.*, 2022).

**Table 2: Application of Brassinoids in fruit crop production**

| Crops | Application Time | Concentration | Response/effect | Reference |
|---|---|---|---|---|
| Litchi | Before anthesis | 1 ppm | Control of fruit cracking | Peng *et al.* (2004) |
| Grapes | At anthesis | 0.001 ppm | Control berry drop | Isci and Gokbayarak*et al.* (2015) |
| Passion fruit | 3 spray at 1 week interval after flowering | 1 ppm | Increase yield | Gomes *et al*. (2006) |
| Grapes | Pea stage and veraison | 0.4 mg/l | Enhanced total anthocyanin | Mani *et al*. (2021) |
| Sweet cherry | Pre-harvest application | 0.75 mg/l | Enhanced shelf life of variety Tak-Danche Mashhad | |
| | Beginning of fruit colour change | 0.4 ppm | Early fruit ripening | Mandava and Wang (2016) |
| Cape gooseberry | At vegetative, flowering and fruiting stage | 16 ppm | Improved physical properties and qualitative aspects of cape gooseberry | Darshan *et al*. (2022) |
| Kiwifruit | Root treatment | 1 µm | Promoted root elongation, lateral root and root hair growth | |

## 2. Jasmonate (JA)

Organic compound found in jasmine flower (*J. grandiflorum*) and chemical formula $C_{12}H_{18}O_3$ isolated in 1971from the culture filterate of a fungus as a plant growth inhibitor. Can be biosynthesized from linolenic acid by the octadecanoid pathway. JA enhances embryo formation, determination and development of flowers and overall fruit set (Zhang *et. al*., 2017). JA and methyl jasmonate protect plants from herbivores and pest by synthesis of enzymes such as proteinase inhibitors and chitinases and volatile aldehydes and oxoacids. JA and MJa improves total antioxidants and phenol content (Nafie *et al*., 2011).Jasmonates are lipid derived compound-signals in plant stress response and development. Role in plant defence was first shown by Farmer and Ryan (1990).

**Functions of Jasmonic Acid (JA)**

1. Root growth/ Seed germination inhibition
2. Secondary metabolite production
3. Stimulates leaf senescence
4. Sherbivory protection
5. Wound response
6. Tendril coiling in plants
7. Pollen development

**Table 3: Application of Jasmonic Acid (JA) in fruit crops**

| Crops | Application Time | Concentration | Response/effect | Reference |
|---|---|---|---|---|
| Mango | Cold storage | 4-10 M | Reduced chilling injury during storage at 7□ | Mani *et al.*(2021) |
| Guava | Matured stage | 1, 10 µmol $L^{-1}$ | Influence on fruit ripening | Silva *et al.* (2017) |
| Citrus | Matured stage | At 10, 20 and 100 mM | Induce fruit abscissions, it helps for mechanical harvesting i.e. easy the detachment of fruits from tree | Hartmond*et al.* (2000) |
| Banana | 3-4 leaf stage | 1.5 mM | Defence against *Fusariumoxysporum*f.sp. Cubense race 4 | Sun *et al.* (2013) |
| Mandarins | Dipping | 0.10 mM | Control post harvest fungal decay (*Penicilliumdigitatum*) | Guo *et al.* (2014) |
| Grapevine | Spraying | 5.00 mM | Control post harvest fungal decay (*Erysiphaenecator*) | Belhadj *et al.* (2006) |
| Pomegranate | Dipping | 0.01-0.1 mM | Increasing of total phenols, anthocyanins | Sayyari *et al.* (2011) |
| Strawberry | At the time of flowering | 0.50 mM | Improved fruit weight and total yield per plant | Darshan *et al.* (2022) |

### 3. Salicylic Acid (SA) :

Salicylic acid ($C_7H_6O_3$) is a monohydroxy benzoic acid (type of phenolic acid and betahydroxy acid). SA derivedfrom the metabolism of salicin. SA has influence on photosynthesis,ion uptake, membrane permeability, enzyme activities, flowering and growth and development of plants (Mani *et al*., 2021).

SA is colorless crystallineacid; ithas influence on photosynthesis, ion uptake, enzyme activities, flowering and growth & development of plants.SA effectively reduced fruit decay, chilling injury, improves fruit firmness and maintained TSS.It is involved in the systemic acquired resistance (SAR) in which a pathogenic attack in one part of the plant induces resistance in other parts (Kohli *et al*., 2018).

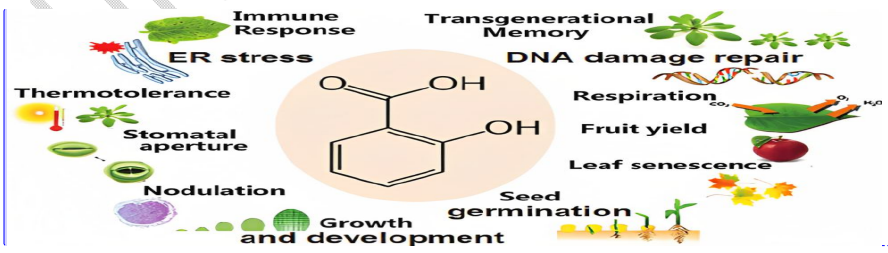


**Figure 2: Role of salicylic Acid ~~(SA)~~**

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**Table 4: Application of Salicylic Acid (SA) in fruit crops**

| Crops | Application Time | Concentration | Response/Effect | Reference |
|---|---|---|---|---|
| Litchi | Mature fruit | 1.0 mM | Reduce pericarp browning, weight loss, decay and maintain anti-oxidant capacity | Kumar *et al.* (2013) |
| Plum | Post harvest treatments | 1.5 mM | Reduced chilling injury, respiration rate, ethylene rate, disease incident | Darshan *et al.* (2022) |
| Pomegranate | Post harvest treatments | 0.4-1 mM | Reduced chilling injury, improved TSS, total phenolic compounds and reduced acidity | Mirdehgham and Ghotbi(2014) |
| Peach | Pre-harvest period | 2 mM | Increase fruit weight, firmness, antioxidant, phenol content and titrable acidity | Erogul and Özsoydan(2020) |
| Strawberry | Spray on the vegetative tissues and fruit every 14 days | 3 mM | Highest fruit yields and lowest percentage of gray mould | Mohamed *et al.* (2017) |
| Grapefruit | Post harvest spray | 12mM | High antioxidants, total carotenoids, total limomin contents, minimum chilling injuries and fruit rots | Ahmed *et al.* (2015) |



## 4. Polyamines (PAs)

Polyamines are strongly basic protein based substances of low molecular weight that exist either free of bound in all plant cells. Biological compounds having variable hydrocarbon chains. Low molecular weight. Aliphatic nitrogen groups. containing two or more amino groups. Range from micromolar to millimolar. All polyamines are positively charged and bind strongly to negatively charged enzymes. The main polyamines in plants include putrescine (Put), spermidine (Spd), and spermine (Spm). Interfere with ethylene biosynthesis lead to a less ripe fruit - quality control in post harvest handling. Cell division, embryo development, delay leaf senescence by preventing chlorophyll loss, defense mechanism against abiotic stress. Polyamines are also implicated in regulation of the flowering process.

**Comment [W9]:** Add two more references

**Role of Polyamines in plants**

1. Cell division
2. Embryo development
3. Flower development
4. Regulate fruit ripening
5. Reduce physiological weight loss

6. Anti-senescence agent
7. Defense mechanism against abiotic stress

**Table 5: Application of Polyamines (PAs) in fruit crops:**

| Crops | Application Time | Concentration | Response/Effect | Reference |
|---|---|---|---|---|
| Mango | At pea stage and 20 days after first spray | 150 ppm | Maximum number~~no.~~ of fruits/panicle, number of fruits/tree and fruit yield and maximum fruit weight | Venu and Ramdevputra (2018) |
| Papaya | After harvesting | 1 mM | Inhibition fruit softening, rate of ethylene production and respiration, total sugars and peel color development | Purwoko*et al*. (2002) |
| Apple | Spraying | 0.25 mM | Highest percentage of fruit set | Sayyad-Amin *et al*. (2018) |
| Citrus | At full bloom | 0.01 mM | Maximum fruit set | Saleem *et al*. (2008) |
| Pistachio nut | Full bloom stage | 1 mM | Maximum yield per shoot | Khezri*et al*. (2010) |
| Strawberry | Foliar application at 4-5 fully expanded leaves | 1.5 mM | Maximum truss number and yield/plant | Movahed *et al*. (2012) |

**5. Triacontanol (TRIA)**

It is found from Alfaalfa (*Medicago sativa* L.) by Ries *et al*. in 1977.Also known as melissyl alcohol or myricyl alcohol. It is found in plant cuticle waxes (Rice) and in beeswax. Induce the production of flowering.Used to help plants suffering nutrient and growth deficiencies.TRIA improves the rate of cell division in a plant that produces larger roots and shoots. Enhance photosynthesis and plant metabolism.

**Comment [W10]:** Add references

**Role of Triacontanol (TRIA):**

1. Increase root length, fresh/dry mass
2. Increase shoot length, fresh/dry mass
3. Increase leaf area per plant
4. Higher photosynthetic efficiency
5. Increases nutrient accumulation
6. Increase yield and yield attributes
7. Improve nitrogen fixation
8. Enhanced translocation and accumulation of sugar

**Table 6: Application of Triacontanol (TRIA) in fruit crops:**

| Crops | Application Time | Concentration | Response/Effect | Reference |
|---|---|---|---|---|
| Strawberry | Two spray were done; 1st at 3-4 leaf stage & 2nd at 15 days after 1st application | 10 µM | Increase in vegetative growth characters, duration of flowering, number of flowers and fruit yield per plant | Rehman *et al*. (2017) |
| | | 100 and 150 ppm | Best in flowering and fruiting parameters of strawberry | Singh *et al*. (2020) |
| Mango | Two foliar spray at pea and marble stage of fruit | 750 mg/l | Minimum physiological loss in weight of fruits | Gaikawad*et al*. (2022) |
| | Foliar spray to panicles at full bloom, pea size stage and at marble size stage of fruits | 300 ppm | Highest fruit set and minimum fruit drop | Kumar *et al*. (2021) |
| Apple | Sprayed at three times (i) At bud stage (ii) three weeks after fruit set (iii) two months after second spray | 10 ppm | Highest fruit set and minimum fruit drop | Zubair *et al*. (2017) |



### 6. 1-MCP (1-Mthylcyclopropene) :

1-MCP is a novel compound that can prolong the shelf life of fresh produce by inhibiting the action of ethylene. It is registered under trade name of SmartFresh™ or EthylBloc™ by Agrofresh Inc. / Rohm and Haas Company (Philadelphia, USA). 1-MCP is a highly volatile gas, thus commercially it is available in an encapsulated form in α-cyclodextrin (CD). The appropriate amount of water or KOH buffer are required as a trigger to release this encapsulated 1-MCP gas molecules. The commercialization of 1-MCP for edible horticulture products was approved in 2002 by EPA. Apples were the first crop to receive registration for receiving 1-MCP treatment commercially.

**Comment [W11]:** Add references

**Role of 1-MCP:**

1. Interact with ethylene sensitive site
2. Reduces the respiration, delays aging and coloration
3. Delay chlorophyll degradation
4. Delays fruit softening and i0proves quality
5. Decreases storage disorders
6. Keep the original flavor for longer time

**Table 7: Application of 1-MCP (1-Mthylcyclopropene) in fruit crops**

| Crops | Application Time | Concentration | Response/Effect | Reference |
|---|---|---|---|---|
| Sapota | After harvesting | 100 nL $L^{-1}$ | Extending the shelf life and increasing the marketable fruits | Thakriya*et al.* (2022) |
| Mango | | 100 or 500 nL $L^{-1}$ | Extend the shelf life and maintain quality of fruit for weeks on ambient storage condition | Ayele *et al.* (2012) |
| Pitahaya fruits | | 600 mg $L^{-1}$ | Reduce ethylene action, slowing the ripening of dragon fruits | Deaquiz*et al.* (2014) |
| Grapes | | 1 mL $L^{-1}$ | Reduces resp5ration and ethylene production | Li *et al.* (2015) |
| Pomegranate | | 1 mL $L^{-1}$ | Reduced development of superficial scald incidence and reduced PPO enzyme activity | Defilippi *et al.* (2006) |

Comment [W12]: Check nl or ml

Comment [W13]: Check nl or ml

## 7. Prohexadione – Ca

The compound acts as a structural mimic of 2-oxoglutaric acid. Prohexadione- Ca is relatively short-lived and possesses very favorable toxicological and ecotoxicological features. It contains Carboxylic group. It is anti- gibberellins.

Comment [W14]: Add reference

**Table 8: Application of Prohexadione – Ca in fruit crops**

| Crops | Application Time | Concentration | Response/Effect | Reference |
|---|---|---|---|---|
| Apple | Spraying at bloom stage | 125 mg $L^{-1}$ | Increased fruit set and control vegetative growth and reduce the incidence and severity of fire blight | Greene (2007) |
| | Spraying at bloom stage | 250 mg $L^{-1}$ | Suppression of additional shoot growth and reduce crop load | Byers *et al.* (2004) |
| Raspberry | Foliar spray in April-May | 100 ppm ($1^{st}$ spray) and 200 ppm ($2^{nd}$ spray) at a 3 week interval | Increasing the number of nodes per meter of cane, increases fruit quality, yield per cane, total antioxidant capacity, total phenolics and anthocyanin contents | Poledica*et al.* (2012) |
| Sweet cherry | Foliar spray at new growth reached about 5-10 cm | 500 mg $L^{-1}$ | Controlling vegetative growth and establish acceptable growth control without negative effect on bloom return, fruit yield and fruit quality | Jacyna and Lipa (2010) |

**Role of Prohexadione-Ca :**

1. It reduces ethylene formation.
2. It reduce alternate bearing
3. It act as alternative for paclobutrazol.
4. It reduces longitudinal shoot growth by blocking dioxygenases
5. It inhibit excessive vegetative growth in fruit trees and other crop plants.

**Brief Review of Some Research Work**

**Brassinosteroid**

**Mango**

**Ramani *et al.* (2016)** noted that application of @ 1.0 ppm 28-homobrassinolide at new leaf initiation stage can be sprayed to get significant increase in shoot length (72.37 cm), shoot girth (71.73 mm), fruits set per panicle (7), fruits retained per panicle (1.84), number of fruit per tree (430.76) and yield per tree (134.93) and minimum days taken for 100% flowering (103 days) in mango cv. Kesar.

**Custard apple**

**Mustafa and Kotb (2018)** found that combined application of 1000 mg /L GA3 plus 0.5 mg /L BRs had positive effect and therefore can be recommended for spray on sugar apple in order to obtain seedless fruit with high quality, so, it can be used as an alternative to hand pollination.

**Jasmonic Acid**

**Acid lime**

**Yamini *et al.* (2021)** studied jasmonic acid @ 3 ppm showed better performance in fruit set (20.98%), number fruits per plants (1234), fruit yield (62.02 kg/plant), fruit breadth (31.36 mm), fruit juice contents (46.16%), fruit volume (52.65 cc) was significant over untreated control.

**Salicylic Acid**

**Papaya**

**Devarakonda*et al.* (2020)** noted that application of salicylic acid @ 150 ppm twice at 45 and 120 DAT was seen on significantly highest number of leaves at 150 DAT (33.87), 180 DAT

(35.72), 210 DAT (43.33) and 240 DAT(43.73)along with total chlorophyll content, chlorophyll 'a' and chlorophyll 'b' content. Further minimum number of days taken for initiation of flowering (112.67 DAT) and days taken for 50% flowering (128.67 DAT) and days taken for first fruit initiation (145.50 DAT) were significantly with the application of sSalicylic acid@ 100 ppm at 45 DAT and 120 DAT(112.67 DAT and 128.67 DAT). Almost a similar trend was observed in Salicylic acid @ 150 ppm at 45 DAT and 120 DAT were height yield (116.06 tons $ha^{-1}$) in papaya.

**Polyamines**

**Pistachio nut**

**Khezri*et al.* (2010)** reported that minimum blank nuts (10.3 %) and deformed nuts (5.7 %) were observed in Spm 1.0 mM and Spm 0.1 mM, respectively at One week before full bloom. Whereas, application of Spm1.0 mM at two weeks after full bloom gave minimum blank nuts (12.3 %) and deformed nuts (4.5 %) in pistachio nut.

**Mango**

**Venu and Ramdevputra (2018)** revealed that foliar application of putrescine @ 150 ppm at full bloom stage gave minimum physiological weight loss (13.04 % and 13.06 %) and spoilage (8.57 % and 8.71 %), whereas maximum days to ripening (16.47 and 16.68) and shelf life (20.53 and 20.73 days) during both year of experiment in Kesar mango. Furthermore, minimum TSS (15.57 and $15.60^0$Brix), reducing sugar (5.07 % and 5.15 %), total sugar (14.48 % and 14.55 %) and maximum ascorbic acid (17.89 and 17.85 mg/100g) were recorded under same treatment.

**Apple**

**Sayyad-Amin *et al.* (2018)** revealed that maximum june fruit set (61.72 %), final fruit set (34.72 %) and index of self-incompatibility (2.41) were recorded under foliar application of spermidine @ 0.25 mM between bud swollen and flower opening stage, while maximum initial fruit set 75.63 % and 74.60 % were recorded with SICS @ 1 ppm and spermine @ 0.05 mM treatment, respectively in apple cv. Golden Delicious. Maximum yield were recorded with SICS @ 2 ppm (2349 g) followed by spermidine @ 0.25 mM (1990.8 g).

**Triacontanol**

**Strawberry**

**Singh *et al*. (2020)** stated that maximum plant height at 120 days (17.20), number of leaves per plant at 120 days (15.13), plant spread at 120 days (21.55 cm) and petiole length at 120 days (18.09 cm) values for vegetative parameters were recorded in Triacontanol (150 ppm) + Pusa hydrogel- 50 gm.Whereas maximum number of flowers per plants (12.32), fruit length (5.05 cm) minimum days taken to first flower (54.96), days taken to first fruit (69.77) were recorded in Triacontanol (150 ppm) + CCC (50 gram) + Pusa hydrogel (50 gm)for two successive years and pooled were recorded in Triacontanol (150 ppm) + Cycocel (500 ppm) + Pusa hydrogel (50 gram).

**Mango**

**Kumar*et al*. (2021)** revealed that among the treatments @ 1 ppm BRs and 300 ppm triaacontanol recorded maximum increase in length of fruit (8.98 cm), girth of fruit (4.95 cm), weight of fruit (182.99 g), volume of fruit (191.02 ml), Mesocarp-pulp (135.31 g), stone weight (22.68 g), peel weight (22.27 g), Pulp: Peel ratio (6.05) and Pulp peel stone percentage (25.43 %) in mango cv. Dashehari.

**1-MCP**

**Sapota**

**Thakriya*et al*. (2022)** studied on different concentration of 1-MCP and stored under ambient temperature and low temperature (12.0 ± 0.5 □). The result revealed that the sapota fruits fumigated with 1-MCP @ 100 nL $L^{-1}$ and stored under low temperature (12.0 ± 0.5 □) had recorded maximum marketable fruits (75.61 %), shelf life (22.39 days), maximum fruit firmness (1.91 kg $cm^{-2}$)and minimum PLW (7.63 %), spoiled fruit (24.40 %), ethylene production (6.53 ppm) and respiratory activity (52.94 mg $CO_2$ $kg^{-1}$ $hr^{-1}$) at $20^{th}$ day of storage.

**Raspberry**

**Milena*et al*. (2012)** stated that application of ProhexadioneCa with 100 ppm ($1^{st}$ application) and 200 ppm ($2^{nd}$ application) at 3week interval result reducing vegetative growth length of canes (211 cm), cane diameter (5.60 mm)and increasing number of fruiting laterals per cane (14.3), number of drupelets per fruit (106), yield per cane (881 g) and soluble solids content (11.3 %) in raspberry.

**Conclusion:**

Different moleculesin plants can act as plant hormones and are involved in various physiological processes in plants. Selective application of new generation plant growth regulators can improve nutritional and economic benefits from crops. New generation plant growth regulators can be used for controlling growth, yield and quality improvement, control ripening, defense against pathogen, control physiological disorders and they are also more efficient and economical than classical PGRs, Healthy and free from toxic effects as they are mainly plant extracts.

Comment [W15]: Rewrite in a better way

**References:**

Comment [W16]: Align as per journal format


1. Ahmed, W.; Ahmed, S.; Ali, L. and Hussan, I. (2015). Effects of pre-harvest spray of salicylic (SA) and methyl jasmonate (MeJA) on the phytochemicals and physiological changes during the storage of grapefruit Cv. ray ruby. *Int. J. Biosci.*, **6**(1): 269-282.
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