## Chapter 10

# ROLE OF GROWTH REGULATORS IN VEGETABLE CROPS

## OBJECTIVES

After studying this chapter, the students will be able to understand:

- Importance of plant growth regulators
- Major plant hormones and their role in growth and development of plants

## INTRODUCTION

As we know that various hormones regulate various function of our body to keep us healthier. Similarly, in plants also, growth hormones play a very vital role in regulating various growth processes. Before, we discuss the effect of plant growth regulators on different vegetable crops, it is essential to understand the basics of plant growth hormones. Hence, this chapter will make you aware about the functions of different plant hormones and their effects in stimulating different growth stages of plants right from seed germination to maturity and senescence. To hasten the different growth processes in a plant, synthetic hormones known as growth regulators are applied. In this chapter, after giving you a clarity about the basics of plant hormones, brief review of research findings has been illustrated on the effect of plant growth regulators (PGRs) in modifying different growth processes of important vegetable crops.

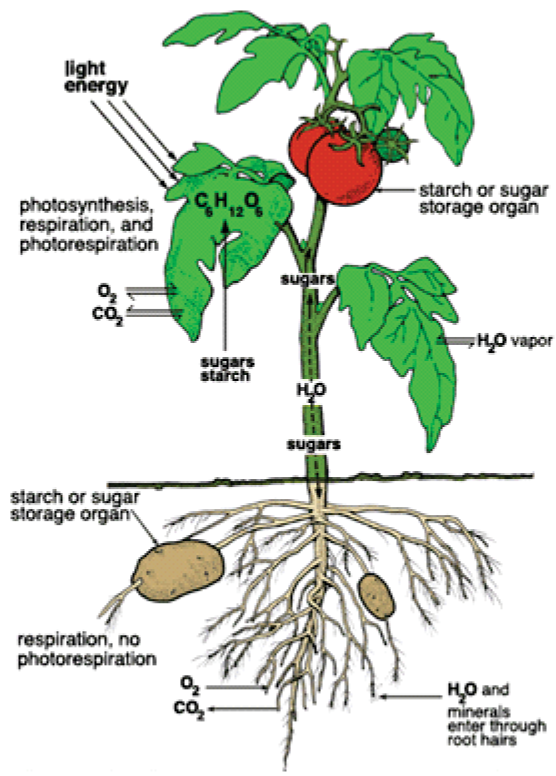
### What do we mean by plant hormones?

Plant hormones are chemicals that regulate the plant growth and are also termed as plant growth substances. They are produced within the plant and occur in very low concentrations. These plant hormones control cellular processes in targeted cells. Plant hormones regulate the seed growth, shape of plant, flowering time, sex of flowers, senescence of leaves and maturity of fruits.

**In animals, glands are present which produce and secrete hormones. In contrary, each plant cell is capable of producing hormones**

They regulate the upward and downward growth of tissues, leaf formation, stem growth, fruit development and ripening, plant longevity and even plant death. Therefore, hormones are vital to plant growth and are also called as growth factors or growth hormones.

Plant hormones may be defined as organic compounds, which at low concentrations promote, inhibit or modify growth, development and differentiation of cells and tissues. Plant hormones are naturally produced within plants. Similar chemicals are also produced by fungi and bacteria which can affect plant growth. A large number of related chemical compounds are artificially synthesized to regulate the growth of different plants both under natural field conditions and artificial or laboratory conditions (tissue culture). These manmade compounds are called **Plant Growth Regulators** or **PGRs**. The external application of these substances on plants can bring about modifications by improved seed germination, rooting, better plant growth, better fruit set, increased rate of ripening and increased yield.




**Source:** http://krishimitrabhopal.blogspot.com

Hormones are transported within the plant by utilizing four types of movements. For localized movement, cytoplasmic streaming within cells and slow diffusion of ions and molecules between the cells are utilized. Vascular tissues are used to move hormones from one part of the plant to another. For example, sugars move from the leaves to the roots and flowers *via* sieve tubes or phloem whereas water and mineral solutes move from the roots to the foliage through xylem.

**Classes of plant hormones**

In general, there are five main classes of plant hormones. Each class has stimulatory as well as inhibitory action. They most often act in tandem with each other with varying degree of one or more interplaying to affect growth regulation.

These five major classes of plant hormones are:

1. **Auxins**
2. **Gibberellins**
3. **Cytokinins**
4. **Abscisic acid**
5. **Ethylene**

1. **Auxins:** Amongst all growth regulators, auxins were the first class of growth regulators to be discovered. Auxin is a generic term for a group of compounds characterized by their coleoptiles capacity to induce elongation in short cells. Auxins positively influence root initiation, stem elongation, bud formation, fruit development and apical dominance. Auxins promote the production of other hormones and in combination with cytokinins, control the growth of stems, roots, and fruits, and convert stems into flowers.

Auxins are toxic to plants at higher concentrations. This property have led to the development of synthetic auxin herbicides such as 2,4-D and 2,4,5-T which are used for weed control. These are most toxic to dicot plants than monocots. Inversely, 2,4-D (herbicide) at low concentration stimulates cell enlargement.

They also promote lateral and adventitious root development and growth. Auxins, especially 1-Naphthalene acetic acid (NAA) and Indole-3-butyric acid (IBA), are also commonly applied to stimulate root growth in the cuttings of plants. The most common auxin found in plants is indole-3-acetic acid or IAA. This indicates that auxins may act as both stimulators and inhibitors of growth.

2. **Gibberellins:** These include a large range of chemicals which are produced naturally within plants and fungi. They are active in regulating dormancy and enhance seed germination, growth of shoots after seed germination, flowering, and fruit setting. They stimulate cell division or cell elongation or both especially in genetically dwarf species, beans, peas *etc.* Gibberellins also reverse the inhibition of shoot growth and dormancy induced by ABA.

3. **Cytokinins:** They form a group of plant hormones which stimulates cell division and shoot formation, and prevent chlorophyll degradation. They also help to delay senescence or the aging of tissues and have similar effects as those of gibberlins in breaking the dormancy. They are responsible for mediating auxin transport throughout the plant and affect internodal length and leaf growth. Cytokinins counter the apical dominance induced by auxins. They in conjunction with ethylene promote abscission of leaves, flower parts, and fruits.

4. **Ethylene:** It is a gaseous hormone and has been commercially used for induction of early maturity and ripening. It plays an important role in the ripening of fruits, inhibition of root growth, abscission or the shedding of plant parts *etc.* Ethylene is also known to play a role in seed and bud dormancy, induction of roots, flowering and stem elongation.

**5. Abscisic acid** (also called ABA): It is named "abscisic acid" because it was found in high concentrations in newly abscised or freshly fallen leaves. It is involved in the abscission of plant organs, retardation of vegetative buds, regulation of fruits ripening and generally in reduction of growth. It accumulates within seeds during fruit maturation and prevents seed germination within the fruit. In plants, ABA plays important role in closing the stomata under water stress.

**Inhibitors:** **These are the diverse group of plant growth substances that inhibit or retard the physiological processes in plants. ABA is the most common naturally occurring inhibitor. It has been reported to act as antiauxin, antigibberelline or anticytokinin.**

**Table 1.** Functions and practical utility of plant growth hormones

| Class | Function(s) | Practical utility | Example |
|---|---|---|---|
| Auxins | Root initiation, cell enlargement and bud formation. | Promote lateral and adventitious root growth, stimulate stem elongation, flower formation and fruit development | Indolacetic acid (IAA), Indolbutyric acid (IBA), Napthaleneacetic acid (NAA), 2,4-dichlorophenoxyacetic acid (2,4-D) |
| Gibberellins | Stimulate cell division and elongation | Increase seed germination, shoot length, flowering, fruit setting and fruit size | Gibberellic acid (GA) |
| Cytokinins | Stimulate cell division and growth | Delay aging of tissues *i.e.* prolonged storage life of vegetables, stimulate bud initiation and root growth | Kinetin, Zeatin |
| Ethylene | Promote ripening and abscission of plant parts | Induce uniform ripening in fruit and vegetables | Ethylene |
| Abscisic acid (ABA) | Inhibit plant growth | Promote flower production by shortening internodes, regulate fruit ripening | Abscissic Acid |

Synthetic plant hormones or PGRs are commonly used in different techniques involving plant propagation from cuttings, grafting, micropropagation, and tissue culture. The propagation of plants by cuttings of fully developed leaves, stems, or roots is performed by gardeners utilizing auxin as a rooting compound applied to the cut surface which promote root initiation. In grafting, auxin promotes callus tissue formation, which joins the surfaces of the graft together. In micropropagation, different PGRs are used to promote multiplication and then rooting of new plantlets. In the tissue-culturing of plant cells, PGRs are used to produce callus growth, multiplication, and rooting.

**Growth retardants:** They are new type of organic chemicals which in general check the rate of growth without any adverse effect. They may retard cell division and cell elongation, and thus plant height is affected without causing mal-formation of leaves and stems *e.g.* CCC (Chlorocholine chloride)

**Role of Plant Growth Hormones in Vegetable Production:**

The role of plant regulators in various physiological and biochemical processes in plants is well known and carries following benefits:

**Benefits of Using PGRs**

- Better seed germination
- Improved plant establishment
- Increased root development
- Efficient nutrient uptake
- Healthy and vigorous crop
- Better fruit set
- Increased retention of flowers and fruits
- Bigger and shining produce
- Break seed dormancy
- Helps in modifying sex expression
- Induce dormancy (CIPC treatment in Potato)
- Enhance keeping quality
- Enhance tolerance to stress conditions
- Significant increase in yield

PGRs can also be used for inducing polyploidy and male sterility in order to overcome inter-species incompatibilities and for production of hybrids.

**Seed Germination:** Pre- sowing treatment of seed with growth regulators has been reported to enhance seed emergence. In tomato, higher seed germination can be achieved by soaking seed in $GA_3$ at 0.5 mg/litre or CIPA at 10 mg/litre or 2,4-D at 0.5 mg/litre.

In brinjal also, soaking seed for 24 hours in GA at 40 mg/litre or IAA at 50 mg/litre or NAA at 25 mg/litre of water resulted in improving seed germination. Similar effects have also been obtained in okra by soaking the seeds for 24 hours in GA at 10 mg/litre or IAA at 100 mg/litre or NAA at 100 mg/litre of water. Soaking of seeds in ethephon at 480 mg/l for 24 h improved germination in muskmelon, bottle gourd, squash melon and watermelon at low temperature. Onion seed germination has been improved by soaking seed in NAA or IBA at 10 mg/litre of water.

**Seed Dormancy:** It is a main problem in potato. The freshly harvested tubers have a rest period for 8 weeks and as a result fail to sprout if sown immediately. This dormancy can be broken by using some chemicals;

- Thiourea (Sodium Potassium thiocynate) @ 1-2% solution which is used as a treatment to cut tubers for 1-1$^{1}/_{2}$ hours and about 1 kg of thiourea is sufficient for 10 quintals of seed tuber. Or
- Tubers are kept in 5ppm solution (5 mg/litre) of $GA_3$ for 10 seconds. Or
- Treat the tuber with acquous solution of thiourea for one hour followed by dipping in 2 ppm solution (2 mg/litre) of GA for 10 seconds.

Lettuce is another vegetable in which treatment with GA has been reported to break seed dormancy induced by high temperatures.

**Flowering:** Induction of flowering in plants which otherwise fail to flower has also been reported with the use of various plant growth regulators. Application of GA at 50 mg/litre to young leaves of non- flowering varieties of potato, when floral buds had just formed, resulted in flower induction in all varieties. GA has been reported to induce early flowering in lettuce.

**Fruit set and yield:** Poor fruit set is a main problem in solanaceous vegetables which is the result of adverse weather conditions at the time of flowering. Plant growth regulators have been reported to enhance fruit set in these vegetable crops under both normal and sub-optimal temperature conditions. In tomato, foliar spray of $GA_3$ or NAA (10 mg/litre), 2,4-D (1-5 mg/litre) at flowering and later increased fruit set and also advanced harvesting. Treatment of seedlings by soaking them for 24 hours in dark in NAA at 0.1 ppm showed higher fruit set, early and increased total yield. In brinjal, application of 2,4-D (2ppm) or NAA (50ppm) or PCPA (20 ppm) after 30-35 days of transplanting promotes fruit set. Similarly, spray of NAA @ 50 ppm or planofix @ 10-20 ppm or tricontanol @ 2 ppm at full flowering stage enhance fruit set at higher temperature in chilli. In bell pepper, foliar application of NAA at 10 ppm at the time of first flower appearance and 15 days later reduces the flower drop, improves fruit set and increases fruit size. In French bean, spray of PCPA @ 2ppm or NAA 5-25 ppm induces fruit set when pods do not set normally at prevailing temperatures.

**Sex Expression:** It is of great significance in most of the cucurbitaceous crops which have monoecious plants. They bear male and female separately on the same plant. Generally, cucurbits bear more male flowers while only female flowers bear fruits. Both auxins and anti-auxins at proper concentration modify sex expression. For example, GA at higher concentration induces maleness but at lower concentration of 10-25 ppm increases the number of female flowers in cucumber. Two sprays of NAA (100 ppm) or etheral (200 ppm), first at 2-leaf stage and second at 4 leaf stage can suppress the number of male flowers and increases the number of female flowers, fruit set and ultimately yield in cucumber.

**Parthenocarpy:** Plant growth regulators stimulate fruit development without fertilization (parthenocarpy). In brinjal, application of 2,4-D at 0.00025% in lanolin paste to the cut end of styles or as foliar sprays to freshly opened flower cluster has been reported to induce parthenocarpy. Spray of GA at 100 mg/litre in cucumber resulted in complete parthenocarpy.

**Fruit Ripening:** Ethephon, an ethylene releasing compound, has been reported to induce ripening in different vegetable crops. Field application of ethephon at 1000 mg/litre at turning stage induce early ripening of fruits thus increased the early fruit yield by 30-35%. Post-harvest dip treatment with ethephon at 500-2000 mg/litre has also been reported to induce ripening in mature green tomatoes.

**Precautions to be taken while application of Growth Regulators**

- Growth substances should be sprayed preferably in the afternoon.
- Avoid spraying in windy hours.
- Spray should be uniform and wet both the surface of leaves.
- Add surfactant or adhesive material like Teepol, Tween-20 with growth substances @ 0.5 to 1.0 ml/l solution.
- Use of growth substances at an appropriate stage of plant growth is of great importance.
- Chemical should be completely dissolved before use over plant.
- Use always fresh solution of chemicals.
- Solution should always be prepared in distilled water only.
- Fine spray can be ensured by hand automizer. It is most economical and effective method of spray.
- Wash the machine/pump after each spraying.
- Repeat the spray with in eight hours if chemical is wash out due to rain.

**Constraints in the use of growth regulators**

- The differences in sensitivity of each plant species or even cultivars to a given chemical treatment prevent easy prediction of the biological effects.
- Higher cost of plant growth regulators.
- Some synthetic plant growth regulators cause human health hazards *e.g.* dominozide.
- Oxytocin is injected in the roots of the plants to produce bigger and more quantity of vegetables. When we consume these vegetables, we are unknowingly consuming this harmful drug causing great loss to our health.
- Lack of basic knowledge of toxicity and mechanism of action.
- Inadequate market potential.
- Difficulty in identification of proper stage of crop at which the growth regulators should be applied.

**References**


1. Chadha, K L and Kalloo G. Advances in Horticulture (Vol. VI). Malhotra Publishing House, New Delhi
2. Fishel F M. Plant growth regulators. EDIS website at http://edis.ifas.ufl.edu.
3. Srivastava L M. 2002. *Plant growth and development: hormones and environment*. Academic Press.
4. Plant Hormones. http://en.wikipedia.org/wiki/Plant_hormone.
5. Wilkins MV. Physiology of plant growth and development. Tata Mc Graw-Hill Publishing Co. Ltd.
6. Roberts JA. Plant growth regulators. Chapman and Hall.


**Activity 1**

You might have seen that banana fruits are made to ripen by the fruit vendor by using ethephone. Now you have clarity that ethylene production in the plant enhances ripening. Take one kg of mature green tomato fruits in a basket and put a few well ripened fruits in this lot. Cover this basket with some cloth and put in the dark. Note the change after few days.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

**Check your progress?**

1. Define plant hormones and plant growth regulators. Enlist different classes of plant hormones with their functions.
2. What are the benefits of using PGRs? Enlist them.
3. Explain the role of PGRs in seed germination of different vegetable crops.
4. PGRs modify sex expression in cucurbits. Justify your statement by giving few examples.
5. Suggest some PGRs with their application rate and stage of application which can enhance fruit set in solanaceous vegetable crops.
6. What precautions should be taken into account while applying plant growth regulators?

**Fill in the blanks:**

1. Artificially synthesized chemicals used to regulate the growth of different plants are called ________________.
2. _______________ were the first class of growth regulators discovered.
3. The most common auxin found in plants is ________________________.
4. __________________ hormones are active in regulating dormancy.
5. _______________________ help to delay senescence.
6. ____________________ play a role in closing the stomata under water stress.
7. Seed dormancy is a problem in ______________ crop and can be broken by using ____________________.
8. Seed germination in tomato can be enhanced by soaking the seed in ________________.
9. __________________ helps in modifying sex expression in cucumber.
10. Fruit set in chilli can be improved by the application of __________________.

**Name the hormone (one word answer) which play an important role in the following growth and development processes**

1. Fruit ripening
2. Counter apical dominance induced by auxin.
3. Prevents seed germination with in fruit
4. Promote flowering in brinjal
5. Increased rooting
6. Plays a role under water stress