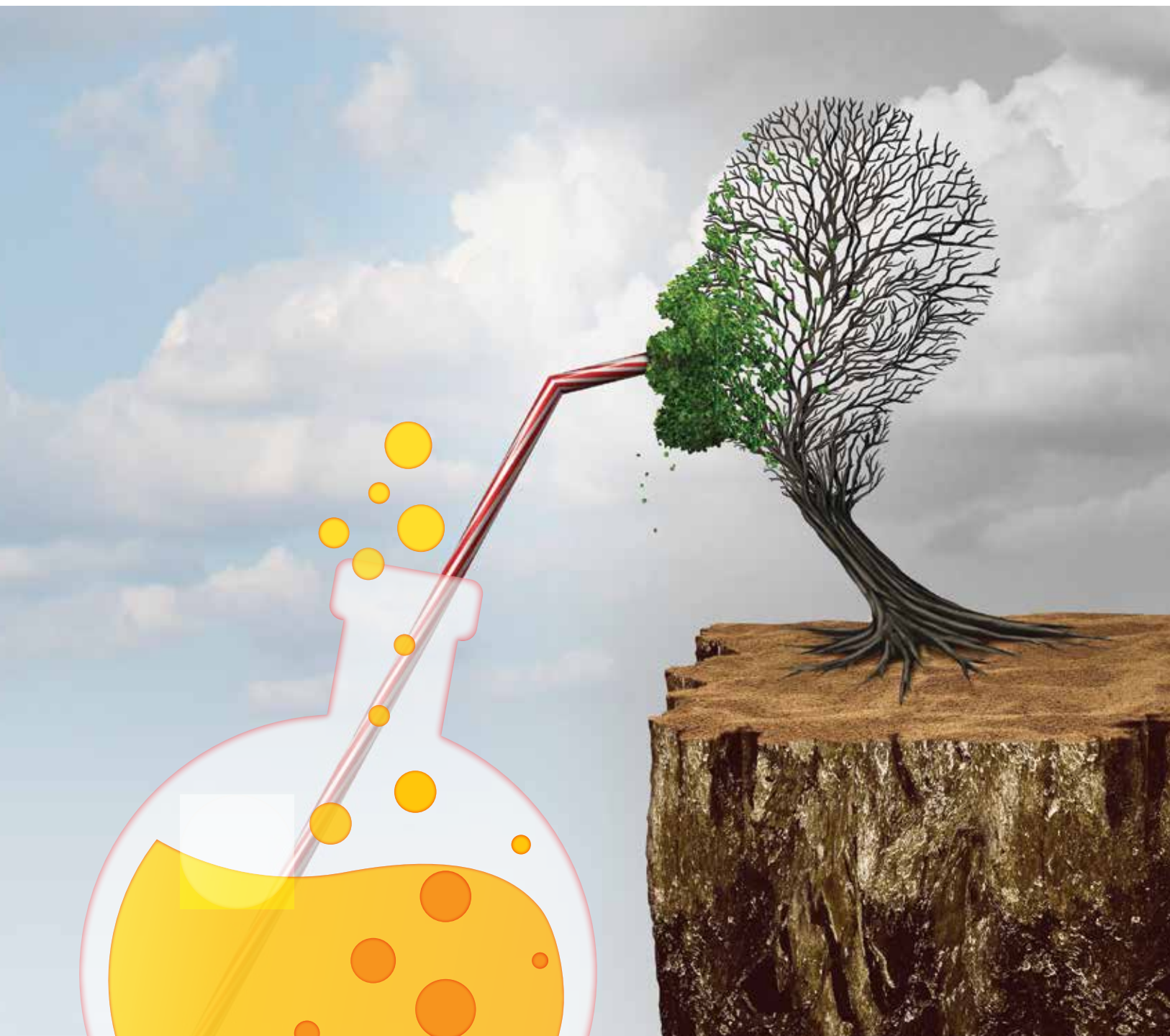


Plant Growth Regulators



Plant Growth Regulators

Plant hormones or plant growth substances are naturally occurring chemicals within plant tissues, which play a regulatory function in growth and development of a plant. These are usually synthesized in certain part of the plant and moved through the plant from one part to another. Chemicals prepared synthetically or through fermentation processes, which mimic the action of naturally occurring growth substances and have an ability to modify plant growth in some way, are termed as plant growth regulators.

The five major classes of plant growth regulators are Auxins, Cytokinins, Gibberellins, Polyamines and Absciscic acid. Each of the growth regulator has a specific role and function which can be used to promote various physiological processes like callus induction, somatic embryogenesis, root formation, inhibition of axillary bud, cell elongation/ division, regulation of organogenesis, soma clonal variation, seed germination etc. Each response is often the result of two or more regulators acting together. Auxins and Cytokinins are by far the most commonly used regulators and usually form an integral part of nutrient media.

Quality Control Parameters

All our products undergo stringent quality control required to maintain consistency and quality. A statistically valid number of samples are withdrawn from each batch as per the defined procedure. We have documented procedures for quality control in accordance with GMP for in process as well as finished products.

We have developed in-house testing criteria for all our products and have defined release criteria. Each lot is passed only if the product conforms to the release criteria. For customized products, additional quality control testing is available on request. Following are some parameters included in the routine testing protocols.

Quality Parameter	Description
Appearance	Individual product is tested for Color, Texture, Nature, Consistency
Solubility	Individual product's solubility is tested against the solvents that they are soluble in
FTIR	Infrared absorption and emission spectra are measured and are matched with the standard spectrum
Assay (HPLC/NaOH/GC/NT/AT titration)	Qualitative/ Quantitative measuring of the analyte is done by carrying out different kinds of assay like HPLC/NaOH/GC/NT/AT * titration depending on the product
Melting Range	Purity of a substance and amount of impurities present in a sample is determined
Water (K.F.)	Water content is determined in the specified product
Ash	Total amount of minerals present is measured after the water and organic matter have been removed by heating in the presence of oxidizing agents
Specific Rotation	Optical purity of the product is determined by measuring the specific rotation of the compounds.
Refractive Index	Refractive index of the substance is determined by identification of the substance and detection of impurities.
Plant Tissue Culture Test	Growth promoting property of the plant growth regulator is assessed by performing <i>in vitro</i> propagation of the plants and assessing their growth promoting properties under proper cultural conditions

* AT - Acid Base Titration, GC - Gas chromatography, HPLC - High Performance Liquid Chromatography, KF - Karl Fisher, NT - Non Aqueous Titration, NaOH - Sodium hydroxide

Role of Plant Growth Regulators in Plant Tissue Culture

VARIOUS STAGES OF PLANT DEVELOPMENT

Callus formation	Somatic embryo- genesis	Root Formation	Shoot Formation	Flowering / Fruiting
→ 2, 4-D	→ 2, 4-D	→ 2, 4-D	→ 2iP	→ Adenine sulphate
→ Daminozide	→ Absciscic acid	→ Dicamba	→ BAP	→ Gibberellic acid
→ IBA	→ BAP	→ IAA	→ KIN	→ IPA
→ Kinetin	→ Dicamba	→ IBA	→ Meta Topolin	→ Paclobutrazol
→ meta Topolin	→ NAA	→ IPA	→ N6 Benzoyladenine	→ Zeatin
→ N6 Benzoyladenine	→ Putrescine 2HCl	→ NAA	→ Spermine	
→ Picloram	→ Thidiazuron	→ NOA	→ TDZ	
→ Spermine			→ Zeatin	
→ Zeatin				

Abbreviations

ABA	Absciscic acid
6-BAP	6-Benzylaminopurine
2, 4-D	2,4-Dichlorophenoxyacetic acid
GA3	Gibberellic acid
IAA	Indole acetic acid
IBA	Indole butyric acid
IPA	Indole-3-propionic acid
JA	Jasmonic acid

Abbreviations

KIN	Kinetin
NAA	α -Naphthalene acetic acid
NOA	Naphthoxyacetic acid
2iP	N6-(2-Isopentenyl) Adenine; (2ip) 6-(G, G-Dimethylallylamino) Purine
2, 3, 5-TIBA	2, 3, 5-Triodobenzoic acid
2, 4, 5-T	2, 4, 5-Trichlorophenoxyacetic acid
TDZ	Thidiazuron



Root formation in *Spathiphyllum* sp. using Indole acetic acid, Product Code PCT0803



Callus formation in *Carnation* sp. using Picloram, Product Code PCT0829

Auxin

The word auxin is derived from the greek word, *auxien* which means "to enlarge or to grow". Auxins promote, mainly in combination with cytokinins, the growth of calli, cell suspensions and organs and also regulate the direction of morphogenesis. Auxins are generally used in plant culture at a concentration range of 0.01-10mg/ml. The choice of auxin and the concentration administered depends on,

- The type of growth and/ or development required
- The rate of uptake and of transport of the applied auxin to the target tissue
- The inactivation (oxidation and/ or conjugation) of auxin in the medium and within the explant
- The natural levels and the endogenous synthesis within the explant
- The sensitivity of the plant tissue to the auxin
- The interaction, if any, between applied auxins and natural endogenous substances

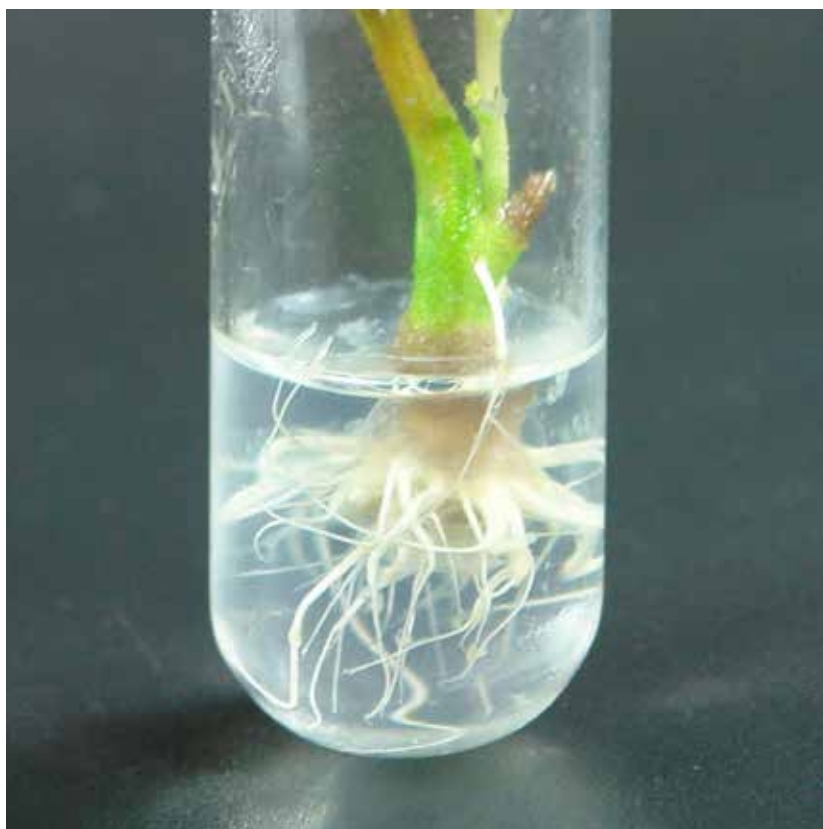
Auxins			
Product Name	Code	Packing	Application
DICAMBA	PCT0834-100MG PCT0834-1G	100 mg 1 gm	Promotes embryogenic callus formation and increases plant growth rate
2, 4-Dichlorophenoxyacetic acid	PCT0825-100GM PCT0825-250GM	100 gm 250 gm	Promotes callus induction, somatic embryogenesis, root formation. Inhibits auxillary bud formation
IAA Solution	PCT1404-1x20ML PCT1404-5x20ML	1x20 ml 5x20 ml	Promotes cell elongation, cell division, adventitious root formation
Indole-3-acetic acid (IAA)	PCT0803-5G PCT0803-25G PCT0803-100G	5 gm 25 gm 100 gm	
IBA Solution	PCT1405-1x20ML PCT1405-5x20ML	1x20 ml 5x20 ml	
Indole-3-butyric acid (IBA)	PCT0804-5G PCT0804-25G PCT0804-100G	5 gm 25 gm 100 gm	Initiates root formation <i>in vitro</i> and callus induction
IPA Solution	PCT1407-1x20ML PCT1407-5x20ML	1x20 ml 5x20 ml	Promotes cell division, cell elongation, autonomal loss of leaves and formation of buds, roots, flowers and fruit
Indole-3-propionic acid (IPA)	PCT0831-5G PCT0831-25G	5 gm 25 gm	
NAA Solution	PCT1402-1x20ML PCT1402-5x20ML	1x20 ml 5x20 ml	Induces root formation, organogenesis, embryogenesis and axillary proliferation of cells. Mostly used for micropropagation of ornamental plants
α-Naphthaleneacetic acid (NAA)	PCT0809-25G PCT0809-100G	25 gm 100 gm	
NOA Solution	PCT1408-1x20ML PCT1408-5x20ML	1x20 ml 5x20 ml	Stimulates fruit set, fruit enlargement, root growth. Promotes cell division, elongation, growth of roots on cuttings and prevents fruit from falling prematurely
2-Naphthoxyacetic acid (NOA)	PCT0810-25G PCT0810-100G	25 gm 100 gm	

Root Formation Induced by Auxins



Multiple Root Formation in *Anthurium* sp. using Indole-3-propionic acid (IPA), Product Code PCT0831

Multiple Root Formation in *Punica granatum* sp. using α -Naphthaleneacetic acid (NAA), Product Code PCT0809



Cytokinins

Cytokinins or CKs are a group of kinins and their purine derivatives that promote cell division and shoot formation either alone or in conjunction with auxin. The first kinin was discovered from degraded autoclaved Herring sperm DNA by Miller in 1955 and was termed as cytokinin owing to its specific effect of cytokinesis. The discovery of cytokinins paved the way for possibility of regeneration of whole plant from plant cells.

Total 18 cytokinins have been reported till date, out of which Zeatin, dihydrozeatin (DHZ) and isopentenyl adenosine (2ip) are naturally occurring while Benzyl adenine (6-BAP), Kinetin, Thiadiazuron (TDZ), Adenine sulphate and Meta-topolin are synthetic. Kinetin and BAP are most commonly used as economical alternatives. TDZ is regarded as a potent cytokinin for the woody plant species. Cytokinins have a highly synergistic effect with auxins and the ratio of these two groups regulates number of processes some of which are mentioned below :

- Promotes cytokinesis leading towards cell division and cell elongation
- Induces differentiation and morphogenesis
- Induces parthenocarp, resistance and overcomes seed dormancy
- Delays senescence and counter apical dominance

Cytokinin			
Product Name	Code	Packing	Application
Adenine Sulphate	PCT0801-10G PCT0801-100G PCT0801-500G PCT0801-1KG	10 gm 100 gm 500 gm 1 kg	Regulates organogenesis and shoot regeneration. Used as a potential cytokinin for in vitro flowering
6-BAP Solution	PCT1403-1x20ML PCT1403-5x20ML	1x20 ml 5x20 ml	Promotes callus induction, Somatic Embryogenesis, Multiple shoot formation
6-Benzyladenine (6-BAP)	PCT0802-1G PCT0802-5G PCT0802-25G	1 gm 5 gm 25 gm	Stimulate cytokinesis in concert with auxin
Kinetin Solution	PCT1406-1x20ML PCT1406-5x20ML	1x20 ml 5x20 ml	Promotes cell division, induces formation of callus and regenerates shoot tissues from callus
Kinetin	PCT0806-1G PCT0806-5G PCT0806-25G	1 gm 5 gm 25 gm	
Meta-Topolin Solution	PCT1410-1x20ML PCT1410-5x20ML	1x20 ml 5x20 ml	Stimulates shoot development, callus development
Meta Topolin	PCT0827-25MG PCT0827-100MG	25 mg 100 mg	
N6 - (2-Isopentenyl) adenine, (2iP)	PCT0807-1G PCT0807-5G	1 gm 5 gm	Induces Somaclonal variation, shoot formation, inhibits root formation
N6 Benzoyladenine	PCT0808-1G	1 gm	Stimulates callus induction and shoot formation
Thidiazuron	PCT0820-250MG PCT0820-1G	250 mg 1 gm	Promotes shoot proliferation, embryogenesis, callus proliferation
Thidiazuron Solution	PCT1409-1x20ML PCT1409-5x20ML	1x20 ml 5x20 ml	
Trans Zeatin Riboside	PCT0814-10MG	10 mg	Stimulates cell division, shoot formation and inhibition of leaf senescence

Cytokinin

Product Name	Code	Packing	Application
Zeatin Solution	PCT1411-1x20ML PCT1411-5x20ML	1x20 ml 5x20 ml	Promotes callus initiation, fruit set, auxiliary stem growth and flowering. Stimulates seed germination and seedling growth
Zeatin	PCT0813-100MG PCT0813-250MG PCT0813-1G	100 mg 250 mg 1 gm	



Multiple Shoot Formation in *Hygrophila sp.* using Spermine, Product Code PCT0821

Multiple Shoot Formation in *Syngonium sp.* using N6-(2-Isopentenyl) Adenine, Product Code PCT0807



Absciscic Acid and Polyamines

Absciscic acid (ABA), discovered by F.T. Addicott in the early 1960s, is often referred to as inhibitory rather than a stimulatory hormone. It is involved in the closure of stomata, bud and seed dormancy and abscission of flowers.

Polyamines are unique as they are effective in relatively high concentration. The concentration ranges from 5 to 500 mg/l. Polyamines influence flowering, plant regeneration and propagation. Several polyamines are available. However, **putrescine**, **spermidine** and **spermine** are commonly used in plant tissue culture and their response is well documented in literature.

Absciscic Acid and Polyamines			
Product Name	Code	Packing	Application
Absciscic Acid	PCT0815-100MG	100 mg	Inhibits cell division, induces somatic embryogenesis
	PCT0815-500MG	500 mg	
	PCT0815-1G	1 gm	
Putrescine Dihydrochloride	PCT0811-1G	1 gm	Induces cell elongation, somatic embryogenesis and plant regeneration
	PCT0811-5G	5 gm	
Spermidine	PCT0812-1G	1 gm	Assists the <i>in vitro</i> process of transcribing RNA. Also contributes to tolerance against drought and salinity in plants
	PCT0812-5G	5 gm	
Spermine	PCT0821-1G	1 gm	Induces callus formation, shoot formation

Gibberellin

Gibberellins are the metabolic products of the fungus *Gibberella fujikuroi* that regulate growth and influence various developmental processes. Gibberellins are plant hormones which share gibbane ring structures and are either dicarboxylic or monocarboxylic. They are assigned, gibberellin numbers (GA_n) and are usually referred to by these than by conventional chemical nomenclature. GA₃ is the most frequently used gibberellin in plant culture and plays important roles such as :

- Promotes seed germination and flowering
- Induces stem elongation especially in rosette plants by process of Bolting
- Delays fruit maturity and senescence which enhances storage time of fruits
- Breaks dormancy, thus results in uniform crop emergence
- Increases synthesis of various hydrolytic enzymes such as α - amylase, ribonuclease and protease in aleurone cells of barley by malting
- Increases fruit growth and parthenocarp

Gibberellin			
Product Name	Code	Packing	Application
Gibberellic acid	PCT0830-1G	1 gm	Influences various developmental processes, including stem elongation, germination, dormancy, flowering, sex expression, enzyme induction, and leaf and fruit senescence
	PCT0830-10G	10 gm	
	PCT0830-100G	100 gm	



Flowering in Plants due to presence of Polyamines

Seed Germination in *Arabidopsis* sp. using Gibberellic acid, Product Code PCT0830



Other Hormones

Besides the major categories of hormones, alternatives hormones are used to induce stimulatory responses in plants. Jasmonic acid regulates plant responses under abiotic and biotic stresses, chitosan improves plantlet quality, picloram aids in callus induction and regeneration of plants from calli while phloroglucinol increases shoot formation and somatic embryogenesis.

Other Hormones			
Product Name	Code	Packing	Application
Ancymidol	PCT0837-50MG PCT0837-100MG	50 mg 100 mg	Inhibits gibberellin biosynthesis, increases bud proliferation. Increases fresh weight over dry weight
Chitosan	PCT0817-500G	500 gm	Enhances secondary metabolite production in cell suspensions and calli of various plant species. Improves plantlet quality in vitro, facilitating subsequent acclimatization of plantlets <i>ex vitro</i>
Chlormequat chloride	PCT0824-1G PCT0824-5G	1 gm 5 gm	Inhibits cell elongation leading to formation of thick and sturdy stalks
Daminozide	PCT0838-1G PCT0838-5G	1 gm 5 gm	Stimulates callus formation and plant regeneration from undeveloped ovules
Dikegulac	PCT0832-500MG PCT0832-1G	500 mg 1 gm	Slows down the elongation process of axillary shoots, helps develop lateral shoots
Glyphosate	PCT0835-1G	1 gm	Inhibits shikimate pathway dependent synthesis of the aromatic amino acids tyrosine, tryptophan and phenylalanine at the apices
Jasmonic Acid	PCT0805-100MG PCT0805-250MG	100 mg 250 mg	Regulates plant responses to abiotic and biotic stresses as well as plant growth and development
Malic hydrazide	PCT0818-100G PCT0818-250G	100 gm 250 gm	Used as systemic mitotic inhibitor for the control of axillary buds. Inhibits corn root elongation
Paclo butrazol	PCT0828-10G PCT0828-25G	10 gm 25 gm	Reduces internodal growth, increases root growth, causes early fruit set and increases seed set in plants
Phloroglucinol	PCT0836-25G PCT0836-100G	25 gm 100 gm	Promotes shoot bud induction, reduces phenolic exudation in plants

Other Hormones

Product Name	Code	Packing	Application
Picloram	PCT0829-5G	500 gm	Promotes callus induction and regeneration of plants from calli
Salicylic Acid	PCT0826-500G	500 gm	Induces biotic and abiotic stress tolerance in plants
Thiabendazole	PCT0819-50G PCT0819-100G	50 gm 100 gm	Promotes <i>in vitro</i> growth actively and active against rots
2, 3, 5-Triiodobenzoic acid (TIBA)	PCT0823-5G	5 gm	Acts as auxin transport inhibitor

Multiple shoot formation and reduction in Internodal Growth in *Musa sp.* using Kinetin, Product Code PCT0806 and Paclobutrazol, Product Code PCT0828



Solubility and Storage Chart of Plant Growth Regulators

Name	Product Code	Solubility	Diluent	Molecular Weight	Working Conc. (mg/l)	Storage Temperature	Stock Solution Storage	Sterilization
Absciscic Acid	PCT0815	Acetone, ether, 1N NaOH	W	264.3	0.1 - 10.0	2-8°C	-0°C	CA/F
Adenine sulphate	PCT0801	0.5M HCl, Water	W	184.2	50 - 250	RT	2-8°C	CA
Ancymidol	PCT0837	DMSO	W	256.3	1.0 - 10.0	2-8°C	-0°C	CA/F
6-BAP	PCT0802	EtOH, Glacial acetic acid, 1N NaOH	W	225.3	0.1 - 5.0	2-8°C	2-8°C	CA/F
Chlorme quat chloride	PCT0824	Water	W	158.1	Upto 500	RT	2-8°C	CA
2, 4-D	PCT0825	95% EtOH, 1N NaOH	W	221	0.01 - 6.0	RT	2-8°C	CA
Daminozide (Alar)	PCT0838	Water, MeOH, acetone, polar organic solvents	W	160.17	0.1 - 10.0	2-8°C	2-8°C	CA/F
Dicamba	PCT0834	Water	W	221.04	0.01 - 10.0	2-8°C	2-8°C	F
Dikegulac	PCT0832	Water, DMSO, EtOH	W	274.27	0.05 - 10.0	2-8°C	-0°C	F
Gibberellic acid	PCT0830	MeOH, EtOH, acetone	W	346.4	0.01 - 5.0	RT	2-8°C	CA/F
Glyphosate	PCT0835	Water	W	169.07	0.01 - 5.0	RT	2-8°C	F
2ip	PCT0807	DMSO, 1N NaOH	W	203.2	1.0 - 30.0	2-8°C	-0°C	CA/F
IAA	PCT0803	Water, EtOH, Acetone, Diethyl ether, chloroform, 1N NaOH	W	175.2	0.01 - 3.0	2-8°C	2-8°C	CA/F
IBA	PCT0804	EtOH, Ether, 1N NaOH	W	203.2	0.1 - 10.0	2-8°C	2-8°C	CA/F
IPA	PCT0831	EtOH, water, 1N NaOH	W	189.2	0.1 - 10.0	RT	-0°C	CA/F
Jasmonic Acid	PCT0805	Water, DMSO, PBS, EtOH	W	210.3	0.01 - 10.0	2-8°C	-0°C	F
Kinetin	PCT0806	HCl, 1N NaOH	W	215.2	0.1 - 5.0	0°C	-0°C	CA/F
Maleic hydrazide	PCT0818	Water, 1N NaOH	W	112.1	0.01 - 10.0	RT	2-8°C	F
meta-Topolin	PCT0827	KOH	W	241.5	0.01 - 5.0	RT	2-8°C	F

Solubility and Storage Chart of Plant Growth Regulators

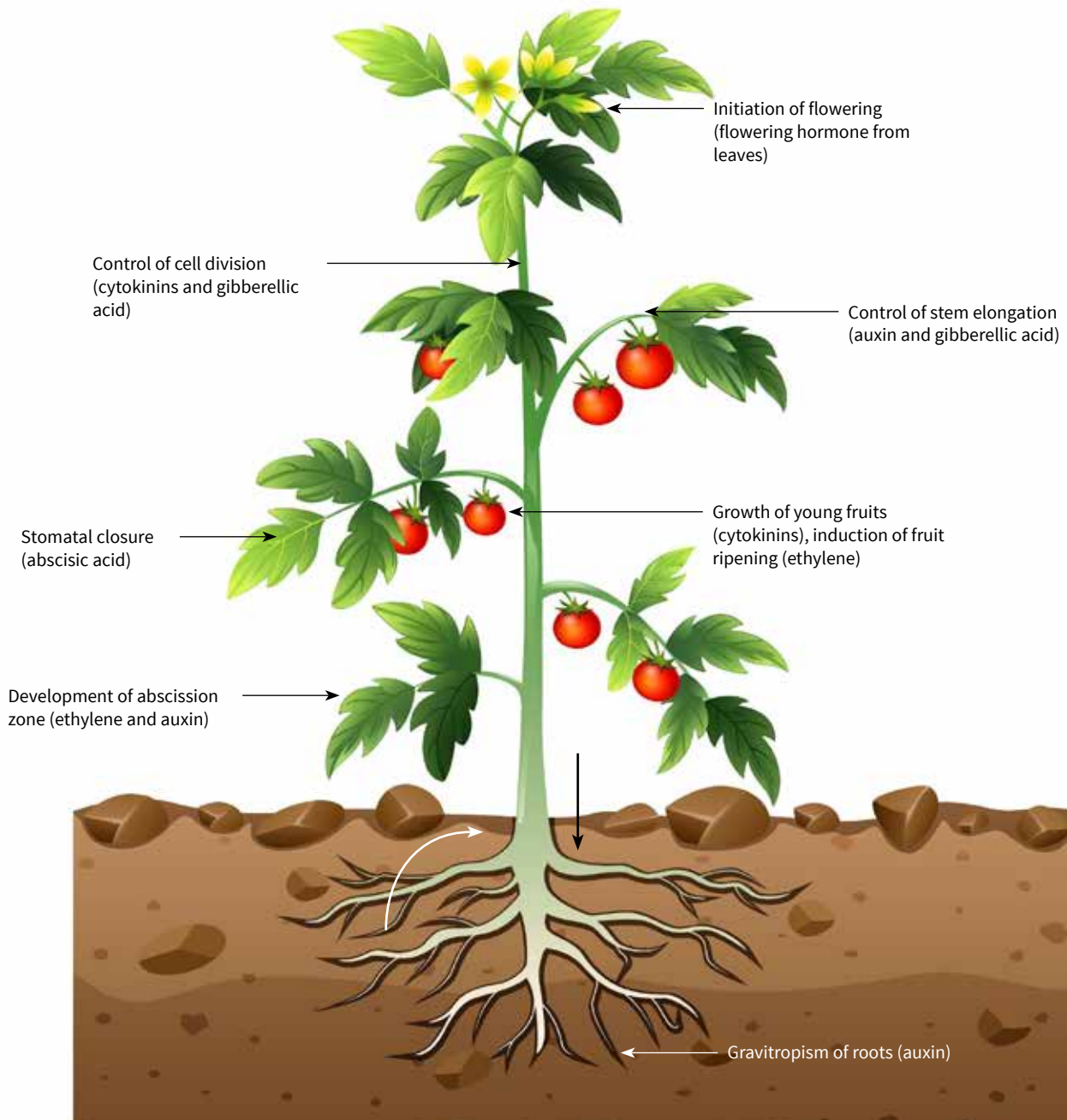
Name	Product Code	Solubility	Diluent	Molecular Weight	Working Conc. (mg/l)	Storage Temperature	Stock Solution Storage	Sterilization
N ₆ -Benzoyladenine	PCT0808	Water, EtOH, DMSO	W	239.23	0.1 - 10.0	2-6°C	-20°C	F
NAA	PCT0809	1M NaOH and Acetone	W	186.2	0.1 - 10.0	RT	0-5°C	CA
NOA	PCT0810	Water, alcohol, 1N NaOH	W	202.2	0.1 - 10.0	RT	2-8°C	CA
Paclobutrazol	PCT0828	Water, acetone, DMSO	W	293.8	0.25 - 0.5	RT	2-8°C	CA/F
Phloroglucinol	PCT0836	Water, EtOH, ether, pyridine, MeOH	W	126.1	Upto 162	RT	0-5°C	CA/F
Picloram	PCT0829	Water, acetone, EtOH, benzene, 1N NaOH	W	241.5	0.01 - 10.0	RT	2-8°C	CA/F
Putrescine dihydrochloride	PCT0811	Water	W	161.1	0.01 - 0.5	RT	2-8°C	F
Salicylic acid	PCT0826	Water, ether, CCl ₄ , benzene, propanol, acetone, EtOH, oil of turpentine, toluene	W	138.12	0.1 - 0.5	RT	2-8°C	CA/F
Spermidine	PCT0812	Water	W	145.25	2 - 10	2-8°C	2-8°C	F
Spermine	PCT0821	Water	W	202.35	5 - 10	2-8°C	2-8°C	F
Thidiazuron	PCT0820	DMSO	W	220.2	0.001 - 0.05	RT	2-8°C	CA/F
2, 3, 5-TIBA	PCT0823	MeOH, 1N NaOH	W	499.8	0.05 - 5.0	2-8°C	-0°C	F
Trans-zeatin riboside	PCT0814	Water, alcohol, DMF, 1N NaOH	W	351.4	0.01 - 5.0	2-8°C	-0°C	F
Zeatin	PCT0813	1N NaOH	W	219.2	0.01 - 0.5	2-8°C	-0°C	CA/F

* CA - Coautoclavable, CA/F - Coautoclavable / filter sterilized, CCL₄ - Carbon tetrachloride, DMSO - Dimethyl sulphoxide, EtOH - Ethanol, HCl - Hydrochloric acid, KOH - Potassium hydroxide, MeOH - Methanol, NaOH - Sodium hydroxide, PBS - Phosphate buffer saline, RT - Room Temperature, W - Water

Note :

- Heat labile (sensitive) PGRs cannot be added directly to the media before autoclaving. Stock solutions of such PGRs are filter sterilized and added into the luke warm autoclaved media in the Laminar Air Flow.
- For critical research use of filter sterilized plant growth regulator is recommended as loss of activity may occur during autoclaving.
- For best results, user must standardize the working concentration as it varies among the plant species.

Hormonal Influence on Plant Growth and Development





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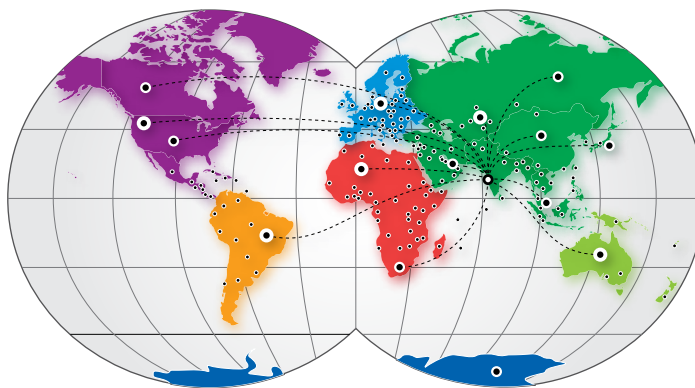
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