

## NEW PRODUCTION TECHNIQUES

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#### **Abstract**

In order to meet the needs of food production techniques, in the history of mankind has been in a constant dynamism. At the beginning changes was more limited than by the discovering of fertilizers and plant protection products, the "green revolution" is provided. However, due to their excessive use damages the ecosystem in recognition of these efforts to re-gained momentum in the development of a more natural production models.

Global climate change, humanity couldn't any afford against natural events, the development of the forces of production models in controlled areas. In this context, the greenhouses with multi-level flats, hydroponic culture vessels that are floating on the oceans, and different type designed production cabinets like domestic refrigerators which have been preparing that are not only a prototype but also offered through the use for food production in home. More recently the movement is comeback towards organic farming in a huge range of production models.

In this work, a considerable effect on the environment leaving negative intensive industrial farming systems, and not cause negative impacts to the environment hydroponic, aerophonic, biodynamic, organic, biological, ecological, integrated, and sustainable production models, with examples were presented. The basic materials use for the production models are summarized. Also the aim of use of plant hormones like auxins, cytokinins, gibberellic acid (GA), abscisic acid (ABA), ethylene, brassinosteroids, salicylic acid (SA), jasmonates (Jm), polyamines, nitric oxide (NO), strigolaktone (SG), and the karrikins for the production of biomass and food productions were given with samples.

**Key Words:** Agricultural systems, green revolution, soilless culture, hormones, organic production

## YENİ ÜRETİM TEKNİKLERİ

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#### **Özet**

Gıda ihtiyacını karşılamaya yönelik üretim teknikleri, insanlık tarihi sürecinde sürekli bir dinamizm içerisinde olmuştur. Değişin başlangıçta daha sınırlı düzeylerde gerçekleşirken özellikle gübreler ve bitki koruma maddelerinin keşfi ile "yeşil devrim" sağlanmıştır. Ancak bunların aşırı kullanımına bağlı olarak ekosisteme verdiği zararların farkına varılmasıyla yeniden daha doğal üretim modellerinin geliştirilmesi gayretleri hız kazanmıştır.



Küresel iklim değişikliği, insanlığın doğal olaylar karşısındaki acziyeti, daha kontrol edilebilen alanlarda üretim modellerinin gelişmesini zorlamaktadır. Bu kapsamda topraksız kültür yapılan seralarla bunların okyanuslarda gemiler üzerinde yüzen çok katlı modelleri ve evlerde buzdolabı gibi yetiştirme kabinleri prototip olmaktan ileri geçerek farklı tasarımlarla kullanıma sunulmaya hazırlanılmaktadır. Daha yeni olarak organik tarıma çok çeşitli üretim modelleri içerisinde geri dönülmeye başlanmıştır.

Bu çalışmada çevreye olumsuz ekiler bırakan endüstriyel yoğunlaştırılmış tarım sistemleri, çevreye olumsuz etki bırakmayan hidrofonik, aerofonik, biyodinamik, organik, biyolojik, ekolojik, entegre ve sürdürülebilir üretim modelleri örneklerle sunulmuştur. Bu üretim modellerinde kullanılan temel girdilerin kullanım amaçları da özetlenmiştir. Aynı zamanda, oksinler, sitokinler, giberellik asit (GA), absizik asit (ABA), etilen, brassinosteroidler, salisilik asit (SA), jasmonatlar (Jm), polyaminler, nitrik oksit (NO), strigolaktonlar (Sg), ve karrikinler gibi bitkisel hormonların biyokütle ve bitkisel gıda üretiminde kullanım teknikleri verilmiştir.

**Anahtar Kelimeler:** Tarım sistemleri, yeşil devrim, topraksız kültür, hormonlar, organik üretim

## AGRICULTURE SYSTEMS

### Short definitions and classifications

A short definition of the agriculture show us that its main purposes are the plant cultivation and animal breeding in order to obtain food and several prime materials witch are deriving from the two activities showed.

A first classification of the agricultural systems was made in 1970, when the agricultural systems where split in two different branches (Treadwell, 2009).

**Intensive agricultural system** based on intensive use of fertilizers, pesticides, irrigation and machinery. Integrated agricultural system a concept adopted to reduce the negative aspects of the intensive agricultural system (wise use of fertilizers, pesticides, irrigation and machinery) with concerns for the environment, and the consumers health

In accordance with the intensification grade of applied technology, or intensification grade of soil use, two different agricultural systems where obtained:

**Extensive agricultural system:** where most of the crops where obtained through the natural resources of the soil (the natural fertility of the soil, water from rains, natural climatic conditions, the natural resistance of plants for pests and diseases). In this kind of systems the global increase of the crops was obtained through the maximization of the agricultural surfaces.

**Intensive agricultural system** was adopted as a solution for the demographical increase of population, but also because of the progress reached in science and technology. The main objective of this system was to obtain higher yields on the cultivated surfaces by increasing the number of agricultural inputs. This system is responsible for solving the problem "food on Earth", but with a high price to pay: *severe degradation of the ecosystems due to intensive use of chemical products.*

Another classification which was developed between years 1980-1990, is based upon the impact of technology in the agricultural ecosystem and on the obtained crop. From this point of view we can observe two different agricultural systems.



**Systems with negative impact** are the industrial system and the intensive system. **Systems without negative impact** are the biodynamic system, the organic system, the biological system, the ecological system, the integrated system, the sustainable system (durable system).

General definitions of the systems without negative impact upon the agricultural ecosystems

**Biodynamic agriculture** is related with the use of biodynamic inputs, derived from organic matter and specific plants. Another aspect of this agriculture is the influence of the moon and other planets in the obtained yield.

**Organic agriculture**; keen on the use of organic fertilization, the humus plays a major role in maintaining the biological stability and the soil fertility.

**Biological agriculture** appeared as a reaction of consumers and medics after the Second World War, preoccupied by the effects of food upon the human health. The biological agriculture is mainly focused by the use of recyclable materials (in form of a compost), obtained through a process of surface fermentation.

**Ecological agriculture** based exclusively on using organic or biological materials that are self-degrading, materials who are offering the ecological stability of the agricultural system.

**Integrated agriculture** with the main objective in reducing the negative impact upon the plant, the soil, the crop, and the environment, due to intensifications of agricultural inputs and technological progress, also this agriculture optimizes the agricultural inputs.

**Sustainable agriculture (Durable agriculture)** through this kind of agriculture is made an agreement between the conventional agricultural systems and the non-conventional ones. This agriculture admits the use of technological inputs, but only in limits which don't affect the environment, and the crops obtained.

### **Green Revolution (Gr)**

Gr refers to a series of research, development, and [technology transfer](#) initiatives, occurring between the 1940s and the late 1960s that increased agriculture production worldwide, particularly in the developing world beginning most markedly in the late 1960s (Gaud, 1968).

The initiatives, led by [Norman Borlaug](#), the "Father of the Gr" credited with saving over a billion people from starvation, involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic [fertilizers](#), and [pesticides](#) to farmers.

The term "Gr" was first used in 1968 by former [United States Agency for International Development](#) (USAID) director [William Gaud](#), who noted the spread of the new technologies: "These and other developments in the field of agriculture contain the makings of a new revolution. It is not a violent [Red Revolution](#) like that of the Soviets, nor is it a [White Revolution](#) like that of the [Shah of Iran](#). I call it the Green Revolution." (Gaud, 1968).



Increased use of various technologies such as pesticides, herbicides, and fertilizers as well as new breeds of high yield crops were employed in the decades after the Second World War to greatly increase global food production.

### **Soilless culture**

Gericke originally defined hydroponics as crop growth in mineral nutrient solutions. Hydroponics is a subset of soilless culture. Many types of soilless culture do not use the mineral nutrient solutions required for hydroponics. Plants that are not traditionally grown in a climate would be possible to grow using a controlled environment system like hydroponics. NASA has also looked to utilize hydroponics in the space program. Ray Wheeler, plant physiologist at Kennedy Space Center's Space Life Science Lab, believes that hydroponics will create advances within space travel. He terms this as a bio regenerative life support system (Anna, 2013).

### **Hydroponic systems**

Hydroponics is a subset of hydro culture and is a method of growing plants using mineral nutrient solutions, in water, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, mineral wool, expanded clay pebbles or coconut husk.

Researchers discovered in the 18th century that plants absorb essential mineral nutrients as inorganic ions in water. In natural conditions, soil acts as a mineral nutrient reservoir but the soil itself is not essential to plant growth. When the mineral nutrients in the soil dissolve in water, plant roots are able to absorb them. When the required mineral nutrients are introduced into a plant's water supply artificially, soil is no longer required for the plant to thrive. Almost any terrestrial plant will grow with hydroponics. Hydroponics is also a standard technique in biology research and teaching.

Hydroponic techniques are Static solution culture, Continuous-flow solution culture, Aeroponics, Passive sub-irrigation, Ebb and flow or flood and drain sub-irrigation, Run to waste, Deep water culture, Bubbleponics, Fogponics, and Rotary. Hydroponic Substrates are Expanded clay aggregate, Grow stones, Coir, Rice Hulls, Perlite, Pumice, Vermiculite, Sand, Gravel, Wood fiber, Sheep wool, Rock wool, Brick shards, and Polystyrene packing peanuts

**Aeroponics** is a system wherein roots are continuously or discontinuously kept in an environment saturated with fine drops (a mist or aerosol) of nutrient solution. The method requires no substrate and entails growing plants with their roots suspended in a deep air or growth chamber with the roots periodically wetted with a fine mist of atomized nutrients. Excellent aeration is the main advantage of aeroponics.

Aeroponic techniques have proved to be commercially successful for propagation, seed germination, seed potato production, tomato production, leaf crops, and micro-greens.<sup>[10]</sup> Since inventor Richard Stoner commercialized aeroponic technology in 1983, aeroponics has been implemented as an alternative to water intensive hydroponic systems worldwide.<sup>[11]</sup> The limitation of hydroponics is the fact that 1 kg of water can only hold 8 mg of air, no matter whether aerators are utilized or not.



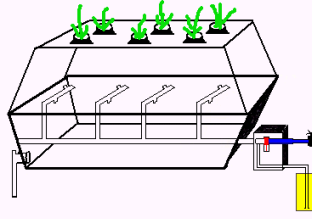


Fig.1. An aeroponics system design

Another distinct advantage of aeroponics over hydroponics is that any species of plants can be grown in a true aeroponic system because the micro environment of an aeroponic can be finely controlled. The limitation of hydroponics is that only certain species of plants can survive for so long in water before they become waterlogged. The advantage of aeroponics is that suspended aeroponic plants receive 100% of the available oxygen and carbon dioxide to the roots zone, stems, and leaves,<sup>[12]</sup> thus accelerating biomass growth and reducing rooting times. NASA research has shown that aeroponically grown plants have an 80% increase in dry weight biomass (essential minerals) compared to hydroponically grown plants. Aeroponics used 65% less water than hydroponics. NASA also concluded that aeroponically grown plants requires  $\frac{1}{4}$  the nutrient input compared to hydroponics. Unlike hydroponically grown plants, aeroponically grown plants will not suffer transplant shock when transplanted to soil, and offers growers the ability to reduce the spread of disease and pathogens. Aeroponics is also widely used in laboratory studies of plant physiology and plant pathology. Aeroponic techniques have been given special attention from [NASA](#) since a mist is easier to handle than a liquid in a zero gravity environment.

### Floating Greenhouses

Global climate change caused by greenhouse- gas emissions means that key climate and hydrological variables will change. We can no longer assume that the future climate can be predicted on the basis of past patterns (Campen and de Zwart, 2004). Regional climate change should not be seen only as a threat; changes to weather patterns could generate opportunities for large-scale innovations (Kabat and Schaik, 2003; Anonymous, 2005). Climate change and sea-level rise present major challenges to each of the world's delta regions, which together harbor about 70% of the world's population and economic resources. The international science and policy communities should develop plans for achieving future sustainability in these vital areas of our planet, using a 'climate proofing' approach. Climate proofing does not mean reducing climate-based risks to zero — an unrealistic goal for any country. The idea is to use hard infrastructure to reduce risks to a quantified level, accepted by the society or economy. This risk can be further combated by 'softer' measures, such as insurance schemes or, as a last resort, evacuation plans. Such climate proofing should be driven by opportunities for technological, institutional and societal innovations, rather than purely by fear of the negative effects of climate change.



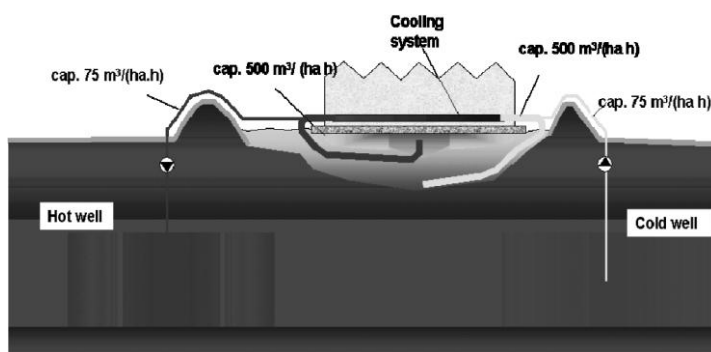


Fig. 2. A floating greenhouse

A future floating city, or hydrometropole, could be further divided so that different risk thresholds are matched to suitable property insurance levels. Finding extra land to store surplus floodwater will require creative solutions. For example, greenhouse horticulture businesses place a high demand on water for irrigating their crops, and are sensitive to both wet and dry climate extremes. Greenhouses and their water reservoirs also cover large surface areas. So integrating water reservoirs into the foundations of greenhouses could both save space and serve as emergency floodwater storage<sup>9</sup>. These ideas are already moving from research ideas to pilot projects in the Dutch city of Naaldwijk.

The major arguments for developing floating greenhouses are (Spliet 2001):

- Multiple use of space on a regional level and adding economic value to open water
- Multiple use of space on the greenhouse level by using the float for other functions
- Environmental friendly / sustainability (energy saving can be achieved by using the surface water for temporarily storage of heat/cold water)
- Risk reduction (no inundations of greenhouses and related crop damage)
- Improvement of the image of the horticultural sector

As a first step in creating a general tool for “floating constructions” a first version of an expert system is set up to support the design engineers with dedicated guidelines for the integral design. Aspects like construction of the floats, location, type of water, type of crop, preferred greenhouse construction, energy system, logistic solutions but also the non-technical aspects like local and international regulations and estimated costs are included. The goal is to help the design engineer with providing guidelines for the final design process and during the interaction with the end-user. The system does not aim to generate a complete detailed design for a floating greenhouse but should support the design engineer by providing the consequences of each decision or added requirement. The architecture of the expert system enables easy expansion to other functions and adding new information e.g. from the first prototype of a floating greenhouse to be built in the autumn of 2004 (Bakker et al., 2005).

## PLANT HORMONES

Growth is complex and coordinated process. External factors such as light, temperature, water, oxygen and carbon dioxide and internal factors such as nutrients and photosynthates show their influence indirectly on growth. Some chemicals show



their direct influence on various stages of growth in relatively less concentration at a place away from the place of their synthesis.

“Plant hormones are low molecular weight compounds produced by plants themselves. They control the germination, growth and response of plants to their environment in minute amounts. The same hormones are produced by many different types of plants”. In contrast to the hormones found in animals, which have a specific function at a certain location and for a certain time, plant hormones have diverse functions at various times and locations.

Phytohormones are also known as Plant Growth Regulators (PGRs). Auxins, Gibberellins and (CKs) promote growth and they are known as Growth promoters. Abscissic acid inhibits growth and it is known as Growth inhibitor. They are all organic compounds, they may resemble molecules which turn up elsewhere in plant structure or function, but they are not directly involved as nutrients or metabolites.

The word hormone is derived from Greek, meaning *set in motion*. Plant hormones affect gene expression and transcription levels, cellular division, and growth. They are naturally produced within plants, though very similar chemicals are produced by fungi and bacteria that can also affect plant growth (Srivastava, 2002). A large number of related chemical compounds are synthesized by humans. They are used to regulate the growth of cultivated plants, weeds, and in vitro-grown plants and plant cells (Roszer, T. 2012).

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 cells are utilized. Vascular tissues are used to move hormones from one part of the plant to another; these include sieve tubes or phloem that move sugars from the leaves to the roots and flowers, and xylem that moves water and mineral solutes from the roots to the foliage.

Not all plant cells respond to hormones, but those cells that do are programmed to respond at specific points in their growth cycle. The greatest effects occur at specific stages during the cell's life, with diminished effects occurring before or after this period. Plants need hormones at very specific times during plant growth and at specific locations. They also need to disengage the effects that hormones have when they are no longer needed. The production of hormones occurs very often at sites of active growth within the meristems, before cells have fully differentiated. After production, they are sometimes moved to other parts of the plant, where they cause an immediate effect; or they can be stored in cells to be released later. Plants use different pathways to regulate internal hormone quantities and moderate their effects; they can regulate the amount of chemicals used to biosynthesize hormones. They can store them in cells, inactivate them, or cannibalize already-formed hormones by conjugating them with carbohydrates, amino acids, or peptides. Plants can also break down hormones chemically, effectively destroying them. Plant hormones frequently regulate the concentrations of other plant hormones (Swarup et al., 2007). Plants also move hormones around the plant diluting their concentrations.

The concentration of hormones required for plant responses are very low ( $10^{-6}$  to  $10^{-5}$  mol/L). Because of these low concentrations, it has been very difficult to study plant hormones, and only since the late 1970s have scientists been able to start piecing



together their effects and relationships to plant physiology (Rost and Weier, 1979; Anonymous, 2013).

### Auxins

There is only one naturally occurring auxin: indole-3-acetic acid (IAA) and this is chemically related to the amino acid tryptophan. There are many synthetic auxins - aromatic compounds with carboxylic side chains often affect plant growth in the same way that IAA does. These are used commercially rather than IAA because they are cheaper and more stable. For example naphthalene acetic acid (NAA) is used to control fruit set and sucker growth on trees after pruning. Indole butyric acid is used to promote rooting in cuttings. Far and away the biggest use of auxin-like compounds is as herbicides (2,4-D and MCPA). Applied at high concentration they promote uncoordinated growth and finally death, particularly in broad-leaved weeds.

Auxins are compounds that positively influence cell enlargement, bud formation and root initiation. They also promote the production of other hormones and in conjunction with CKs, they control the growth of stems, roots, and fruits, and convert stems into flowers (Osborne and McManus, 2005). Auxins affect cell elongation by altering cell wall plasticity. They stimulate cambium, a subtype of meristem cells, to divide and in stems cause secondary xylem to differentiate. Auxins act to inhibit the growth of buds lower down the stems (apical dominance), and also to promote lateral and adventitious root development and growth. Leaf abscission is initiated by the growing point of a plant ceasing to produce auxins. Auxins in seeds regulate specific protein synthesis (Walz et al., 2002), as they develop within the flower after pollination, causing the flower to develop a fruit to contain the developing seeds. Auxins are toxic to plants in large concentrations; they are most toxic to dicots and less so to monocots. Because of this property, synthetic auxin herbicides including 2,4-D and 2,4,5-T have been developed and used for weed control. Auxins, especially 1-Naphthaleneacetic acid (NAA) and Indole-3-butyric acid (IBA), are also commonly applied to stimulate root growth when taking cuttings of plants. The most common auxin found in plants is indole-3-acetic acid or IAA. The correlation of auxins and CKs in the plants is a constant ( $A/C = \text{const.}$ ).

Several developmental responses of plants are under the control of auxins. Synthetic auxins are more effective than natural auxins because are not destroyed by enzymes and can persist in the plant body for several days after application.

Auxin is mainly synthesized at the apex of stem and its branches and to some extent in root apex. Auxins predominantly move in basipetalous manner and some move in acropetalous manner. This movement is in 3:1 ratio. Auxin translocation is 10 mm/hour.

IAA is synthesized from the aromatic amino acid Tryptophan. Zn is essential for auxin synthesis. It has an indole ring with nitrogen and a side chain having carboxylic group.

### Auxin effects

**Plant propagation;** Root formation in stem cuttings by synthetic auxins such as NAA, IBA and natural auxin IAA when applied at low concentrations promote the induction of roots in stem cuttings and play a role in vegetative propagation of economically useful plants. Due to this property, auxins are used for rapid multiplication of useful plants in horticulture. IBA is the most effective auxin to induce root formation in stem





cuttings. PGRs are commonly used in a number of different techniques involving plant propagation from cuttings, grafting, micro propagation, 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; the auxins are taken into the plant and promote root initiation. In grafting, auxin promotes callus tissue formation, which joins the surfaces of the graft together. In micro propagation, 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 (Maji et al., 2002).

**Fruit fall;** Auxins like IBA and NAA when used as foliar spray prevent premature falling of fruits. Hence increase the yield.

**Herbicidal activity;** Synthetic auxins such as 2,4 - D and 2,4,5 – T are used as weed killers to eradicate dicot weeds in monocot crops, pastures and lawns.

**Female flower formation;** Auxins increase the yield in cucurbits by increasing the formation of female flowers.

**Cell elongation;** Auxins cause growth by promoting cell elongation. They promote cell enlargement in tissue culture. They cause **xylem** differentiation.

**Tropic movements;** Growth movement of plant or its organ in response to external stimulus is called as tropic movement. Auxins cause positive phototropism in stem and positive geotropism in root.

**Apical dominance;** Dominance of apical bud over axillary or lateral bud in terms of growth due to high amount of auxin in the axillary buds is called as **apical dominance**. High auxin concentration that promotes growth in the terminal bud inhibits growth in the axillary buds. It is evident in plants like *Casuarina*, *Polyalthia* and *Eucalyptus*. When apical bud is removed, lateral growth is activated. *Thimann* and *Skoog* experimentally proved the movement and accumulation of auxin from the apical bud towards axillary buds. Decapitation of apical buds prevents the supply of auxins to the axillary buds and results in the elimination of apical dominance.

### **Parthenocarpy**

Formation of fruits without the act of fertilization is called as Parthenocarpy. Such fruits are seedless.

Auxin induced parthenocarpic fruit development was first noticed in orchids.

**Sex determination,** in high concentrations, auxins promote the formation of female flowers in plants like Cucumber.

### **Cytokinins (CKs)**

There are a number of naturally occurring CKs all related to the nucleotide adenine. They can occur as the free base or as a riboside. Synthetic CKs include benzyl adenine and kinetin. CKs are used in tissue culture media, and for growth control in fruit.

These have little application in agriculture and horticulture when compared with auxins and gibberellins.



The cytokinin zeatin, the name is derived from *Zea*, in which it was first discovered in immature kernels.

CKs are a group of chemicals that influence cell division and shoot formation. They were called kinins in the past when the first CKs were isolated from yeast cells. They also help delay senescence or the aging of tissues, are responsible for mediating auxin transport throughout the plant, and affect internodal length and leaf growth. They have a highly synergistic effect in concert with auxins, and the ratios of these two groups of plant hormones affect most major growth periods during a plant's lifetime. CKs counter the apical dominance induced by auxins; they in conjunction with ethylene promote abscission of leaves, flower parts, and fruits.<sup>[14]</sup> The correlation of auxins and CKs in the plants is a constant ( $A/C = \text{const.}$ ).

### CKs effects

**Shelf life (freshness period of fruits or leaves);** preharvest spray of CKs on leafy vegetables such as Asparagus, Spinach and Lettuce make them remain fresh for several days after harvest.

**Vase life (freshness period of cut flowers in vases);** Flowers like Dianthus and Poinsettia having their cut ends dipped in **BAP** solution remain fresh in flower vases for several days.

**Cell Division;** Inducing cell division is the main influence of CKs.

**Cell expansion;** Cytokinin treated soybean leaf discs and Radish cotyledons showed phenomenal increase in size due to more cell elongation.

**Morphogenesis (organ formation);** CKs promote organogenesis when used along with auxins. Skoog and his associates showed the formation of roots in callus in high auxin to low cytokinin concentrations. They also demonstrated the formation of stem, leaves and buds in high cytokinin to low auxin concentration.

**Delay in Senescence;** Aging or yellowing of leaves is called as **Senescence**. It is due to break down or poor synthesis of chlorophyll, RNA and proteins. Senescence is followed by death of organ or plant. Leaves with proper concentrations of CKs remain green and healthy.

**Stomatal Opening;** CKs promote stomatal opening and there by transpiration by inducing the accumulation of more  $K^+$  concentration in the guard cells.

**Young embryos** are rich in CKs. These are mostly synthesized in the root and later transported to shoot system.

### Gibberellins (GAs)

GAs are derived from the isoprenoid pathway. GAs are used commercially to break dormancy of "difficult" seeds, and to promote set of grapes and other fruits. Many growth retardants used on flowering pot plants, woody plants and turf are "anti-gibberellins". Compounds such as ancymidol and uniconazole block GA synthesis and produce dwarf plants. Genetic dwarfs are often deficient in gibberellin (Grennan, 2006).

GAs are important in seed germination, affecting enzyme production that mobilizes food production used for growth of new cells. This is done by modulating chromosomal transcription. In grain (rice, wheat, corn, etc.) seeds, a layer of cells



called the aleurone layer wraps around the endosperm tissue. Absorption of water by the seed causes production of GA. The GA is transported to the aleurone layer, which responds by producing enzymes that break down stored food reserves within the endosperm, which are utilized by the growing seedling. GAs produces bolting of rosette-forming plants, increasing internodal length. They promote flowering, cellular division, and in seeds growth after germination. GAs also reverse the inhibition of shoot growth and dormancy induced by ABA (Tsai et al., 1997). These are discovered in Japan in connection with *bakanae disease of rice* caused by *Gibberella fujikuroi*. The asexual stage of the fungus is *Fusarium moniliformae*. The symptoms of bakanae disease or foolish seedling disease are 1. excessive tallness, 2. thin and pale stem, 3. less tillering, and 4. little grain production.

Sawada discovered that some substance secreted by the fungus is responsible for the disease. Kurasawa induced bakanae symptoms in healthy rice seedlings by applying the extracts of the fungus. Yabuta and Sumuki isolated and crystallized the substance and gave the name Gibberellic acid.

Gibberellins are large group of Phytohormones. So far about 110 different types of gibberellins have been discovered from different plant groups. They are named in abbreviated form as GA1, GA2, GA3 etc. GA3 (C<sub>19</sub>H<sub>22</sub>O<sub>5</sub>) is also known as Gibberellic acid. It is the most commonly present gibberellin in plants. These are diterpenoid compounds and usually consist of 20 carbon atoms. e.g. GA20. A few of them have 19 carbon atoms e.g. GA1, GA3, GA4 and GA7. These are synthesized from acetyl coenzyme A molecules, and mainly promote cell elongation like auxins.

### GAs effects

**Grape industry;** Gibberellins are extensively used in grape industry to increase grape production. They induce the formation of seedless fruits. They increase the size of fruits; fruits per bunch, and number of bunches in each plant. It increases the sugar content of grapes. They promote more elongation of peduncle. Hence proper distance is maintained between the fruits of a bunch. Such fruits are not susceptible to fungal and insect attack.

Less tight packing increases fruit size.

**Orange orchards,** preharvest foliar spray of gibberellins on citrus plants delays fruit ripening. It delays pigment formation in rind, softening of flesh. Such fruits are not damaged during storage and transportation.

**Flowering,** it increases the production of flowers in Roses, Rhododendrons and Poinsettias.

**Sugarcane;** Gibberellin application increases size and sugar content in the canes.

**Seed production;** GA<sub>4</sub> and GA<sub>7</sub> mixtured application increases seed production in conifers.

**Seed germination;** in cereal grains like barley, during germination, the embryo synthesizes gibberellins and these are transported to the aleurone layer of endosperm. In the aleurone layer, gibberellins promote the synthesis of  $\alpha$  - amylase, which hydrolyses the starch of endosperm into sugars. The energy liberated during the oxidation of sugars in respiration is utilized for seed germination.



**Malt production;** high and superior quality malt is obtained from gibberellin treated germinating seeds. It is used in making beverages.

**Removable of genetical dwarfism;** in genetically dwarf plants the gene for gibberellin synthesis is blocked due to gene mutation. Due to this cell elongation in the internodes is blocked resulting in shorter internodes and dwarfness in plant. When gibberellins are applied in dwarf plants like pea, maize etc. cell elongation is promoted in the cells of internodes and internodal length is increased.

**Bolting and flowering;** during the vegetative growth of plants like Cabbage and Cauliflower, the plants show bush like growth (Rosette formation) due to less elongation of internodes, this in return is due to less concentration of Gibberellins. Sudden elongation of the stem just before flowering due to excessive synthesis of Gibberellins in such plants is called as **Bolting**. In several plants Gibberellins promote flowering.

**Formation of parthenocarpic fruits;** when gibberellins are applied on flowers prior to their opening; they promote the formation of seedless fruits in plants like grapes and tomato.

**Sex determination;** Gibberellins promote the formation of more male flowers in plants like Cucurbita and Cannabis (Yamaguchi and Kamiya, 2000).

#### **Abscisic acid (ABA)**

ABA is one of two related compounds (the other is xanthoxin) that are in the isoprenoid group and related to carotenoids ABA is a very expensive material and so far there are no synthetic analogs or practical uses. ABA is one of the most important plant growth regulators. The name "abscisic acid" was given because it was found in high concentrations in newly abscised or freshly fallen leaves. It is produced in the leaves of plants, originating from chloroplasts, especially when plants are under stress. In general, it acts as an inhibitory chemical compound that affects bud growth, and seed and bud dormancy. It mediates changes within the apical meristem, causing bud dormancy and the alteration of the last set of leaves into protective bud covers.

In plant species from temperate parts of the world, it plays a role in leaf and seed dormancy by inhibiting growth, but, as it is dissipated from seeds or buds, growth begins. In other plants, as ABA levels decrease, growth then commences as gibberellin levels increase. Without ABA, buds and seeds would start to grow during warm periods in winter and be killed when it froze again. Since ABA dissipates slowly from the tissues and its effects take time to be offset by other plant hormones, there is a delay in physiological pathways that provide some protection from premature growth. It accumulates within seeds during fruit maturation, preventing seed germination within the fruit, or seed germination before winter. Absciscic acid's effects are degraded within plant tissues during cold temperatures or by its removal by water washing in out of the tissues, releasing the seeds and buds from dormancy (Kermode, 2005).

In plants under water stress, ABA plays a role in closing the stomata. Soon after plants are water-stressed and the roots are deficient in water, a signal moves up to the leaves, causing the formation of ABA precursors there, which then move to the roots. The roots then release ABA, which is translocated to the foliage through the vascular

system<sup>[7]</sup> and modulates the potassium and sodium uptake within the guard cells, which then lose turgidity, closing the stomata (Else et al., 2001; Yan et al., 2007).

ABA exists in all parts of the plant and its concentration within any tissue seems to mediate its effects and function as a hormone; its degradation, or more properly catabolism, within the plant affects metabolic reactions and cellular growth and production of other hormones.<sup>[10]</sup> Plants start life as a seed with high ABA levels. Just before the seed germinates, ABA levels decrease; during germination and early growth of the seedling, ABA levels decrease even more. As plants begin to produce shoots with fully functional leaves, ABA levels begin to increase, slowing down cellular growth in more "mature" areas of the plant. Stress from water or predation affects ABA production and catabolism rates, mediating another cascade of effects that trigger specific responses from targeted cells. Scientists are still piecing together the complex interactions and effects of this and other phytohormones.

### ABA effects

**Dormancy;** it is growth-inhibiting substance that promotes the senescence of leaves and induction of dormancy in buds and seeds. It is inactive state of bud or embryo of seed in which the growth is suspended for specific length of time due even in favorable conditions. ABA induces seed and bud dormancy. Pre – harvest spray of ABA on potato crop **prevents the sprouting in potatoes** during storage.

**Stomatal closure;** in water stress conditions, more abscissic acid is synthesized in the plant. This abscissic acid promotes the closing of stomata and thereby decreases transpiration. It also helps in crop survival during dry spell by acting as **antitranspirant**.

**Formation of perennating buds;** when the water level decreases in the ponds, ABA promotes the formation of these buds in plants like Lemna. These buds survive in unfavorable conditions at the bottom of the pond. With the monsoon showers, they become active and develop into plants.

**Senescence of leaves;** it promotes senescence or yellowing of leaves prior to leaf fall.

### Ethylene

Ethylene is the only gaseous hormone in the plant world; it is a simple hydrocarbon gas that is derived from the amino acid, methionine, via an unusual cyclic compound which is also an amino acid in all cells, ACC (1-aminocyclopropane-1-carboxylic acid). Ethylene is considered as a hormone with regulatory role on senescence. Ethylene has very limited solubility in water and does not accumulate within the cell but diffuses out of the cell and escapes out of the plant. Its effectiveness as a plant hormone is dependent on its rate of production versus its rate of escaping into the atmosphere. Ethylene is produced at a faster rate in rapidly growing and dividing cells, especially in darkness. New growth and newly germinated seedlings produce more ethylene than can escape the plant, which leads to elevated amounts of ethylene, inhibiting leaf expansion. As the new shoot is exposed to light, reactions by phytochrome in the plant's cells produce a signal for ethylene production to decrease, allowing leaf expansion.

Since there are practical difficulties in the application of ethylene in field conditions, it is used in the form of



**Ethephon** (2 – chloroethyl phosphonic acid). Ethephon is ethylene releasing substance.

### Ethylene effects

**Cell growth and cell shape;** when a growing shoot hits an obstacle while underground, ethylene production greatly increases, preventing cell elongation and causing the stem to swell. The resulting thicker stem can exert more pressure against the object impeding its path to the surface. If the shoot does not reach the surface and the ethylene stimulus becomes prolonged, it affects the stem's natural geotropic response, which is to grow upright, allowing it to grow around an object.

**Stem diameter and height.** When stems of trees are subjected to wind, causing lateral stress, greater ethylene production occurs, resulting in thicker, sturdier tree trunks and branches.

**Fruit-ripening:** Ethylene is fruit ripening hormone, enhances fruit ripening in plants like Apple, Banana, water-melon and Tomato etc. Hence it is referred has fruit ripening hormone. Unripe fruits can be made ripened by exogenous application of ethylene. Normally, when the seeds are mature, ethylene production increases and builds-up within the fruit that resulting in a climacteric event just before seed dispersal. The nuclear protein Ethylene Insensitive2 (EIN2) is regulated by ethylene production, and, in turn, regulates other hormones including ABA and stress hormones (Wang et al., 2007). Ethephon is used to promote ripening on the tree, leaf abscission in ornamentals, and growth control in seedlings.

**Flowering;** it promotes synchronous flowering and fruit ripening in Pineapple. So the cost of harvest can be minimized. It delays or inhibits flowering in many plants.

**Rubber plantations;** it enhances the exudation of latex from cut regions of rubber plants.

**Coffee plantations;** it improves the color and quality of coffee berries.

**Tobacco crop;** it promotes uniform senescence of leaves. So the number of picking of tobacco leaves can be minimized. It decreases nicotine content.

**Triple Response Growth;** Inhibition of **Stem elongation**, Inducing **stem thickening** and causing **transverse geotropism** in stem together known as Triple response growth. It is induced by Ethylene.

**Other effects;** it promotes leaf abscission. It induces flower senescence. It promotes female flower formation in cucurbits. It removes or inhibits apical dominance. It promotes growth or divisions at wounded regions and plays a role in **wound healing**.

### Other known hormones

**Brassinosteroids** are a class of polyhydroxysteroids, a group of plant growth regulators. Brassinosteroids have been recognized as a sixth class of plant hormones, which stimulate cell elongation and division, gravitropism, resistance to stress, and xylem differentiation. They inhibit root growth and leaf abscission. Brassinolide was the first identified brassinosteroid and was isolated from extracts of rapeseed (*Brassica napus*) pollen in 1979

(Grove et al., 1979).





**Salicylic acid (SA)** activates genes in some plants that produce chemicals that aid in the defense against pathogenic invaders. SA describes as plant hormone and painkiller. By the synthesis of SA, plants recognize PAMPS (pathogen-associated molecular patterns). Flagellin is an abundant bacterial protein recognized by plant cells. Some pathogens elicit a stronger defense response. The hypersensitive response involves cell death. The hypersensitive response seals the pathogen in a tomb of dead cells, Systemic Acquired Resistance (SAR)

**Jasmonates** (Jasmonic acid, JA) are produced from fatty acids and seem to promote the production of defense proteins against herbivory that are used to fend off invading organisms. JA induces the expression of anti-herbivorous chemicals and volatiles. JA stimulates production of volatile signaling compounds. Herbivore-induced volatiles are recognized by carnivorous and parasitoid insects. They are believed to also have a role in seed germination, and affect the storage of protein in seeds, and seem to affect root growth. JA induced changes in gene expression.

**Plant peptide hormones** are encompasses all small secreted peptides that are involved in cell-to-cell signaling. These small peptide hormones play crucial roles in plant growth and development, including defense mechanisms, the control of cell division and expansion, and pollen self-incompatibility (Lindsey, 2002).

**Polyamines** are strongly basic molecules with low molecular weight that have been found in all organisms studied thus far. They are essential for plant growth and development and affect the process of mitosis and meiosis.

**Nitric oxide (NO)** is serves as signal in hormonal and defense responses (e.g. stomatal closure, root development, germination, nitrogen fixation, cell death, stress response (Shapiro, 2005). NO can be produced by a yet undefined NO synthase, a special type of nitrite reductase, nitrate reductase, mitochondrial cytochrome c oxidase or non-enzymatic processes and regulate plant cell organelle functions e.g. ATP synthesis in chloroplasts and mitochondria (Roszer, 2012).

**Strigolactones**, implicated in the inhibition of shoot branching (Gomez-Roldan et al., 2008).

**Karrikins**, a group of plant growth regulators found in the smoke of burning plant materials that have the ability to stimulate the germination of seeds.

### Potential medical applications

Plant stress hormones activate cellular responses, including cell death, to diverse stress situations in plants. Researchers have found that some plant stress hormones share the ability to adversely affect human cancer cells. For example, sodium salicylate has been found to suppress proliferation of lymphoblastic leukemia, prostate, breast, and melanoma human cancer cells (Fingrut and Flescher, 2002). Jasmonic acid, a plant stress hormone that belongs to the jasmonate family, induced death in lymphoblastic leukemia cells. Methyl jasmonate has been found to induce cell death in a number of cancer cell lines.

### THE ORGANIC HORTICULTURAL SYSTEM

The original philosophy that guided organic farming emphasized the use of on-farm or local resources and avoided the use of synthetic fertilizers and pesticides (Treadwell et al., 2003). The prevailing approach was to rely on biological and ecological



processes for soil fertility and pest control, and was accomplished through the use of crop rotations, the addition of crop residues and animal manures to the soil and the use of biological pest control to maintain soil productivity and tilth, supply plant nutrients, and regulate insects, weeds and diseases. Original organic farmers saw these strategies as a way to produce food for their community in a manner that was *in synchrony with nature*.

Organic farming is practiced in approximately 120 countries throughout the world and more than 31 million hectares are currently under organic management (Willer and Yussefi, 2007). Countries with the largest land area under organic production are Australia (10 million hectares), Argentina (3 million hectares) and Italy (1.2 million acres) (Willer and Yussefi, 2007).

In the US, there are over 10,500 certified organic farms comprising one million hectares. In 2003, the United States and the European Union (EU) market accounted for 95% of the global organic foods market (Dimitri and Olberholtzer, 2005). Although the US market is slightly larger than the EU, the proportion of organically managed land is greatest in the EU compared to the United States and other comparable countries due in part to governmental price supports, economic incentives for land conversion, and increased funding for research, education, and marketing (Dimitri and Olberholtzer, 2005). Industry experts predict that the organic industry will continue to expand at the current rate on the globe and there is no consensus when market saturation may occur.

### Certification process in US

Any farmer with gross organic sales greater than \$5,000 a year advertising their products as organic is required to be certified. If gross sales are less than \$5,000 a year, certification is optional, and although farmers are allowed to verbally communicate that they are following organic standards, regulations prohibit the use of the USDA seal or the words "certified organic" on any label or advertisement. False claims are subject to a \$10,000 fine and possible legal action for every violation.

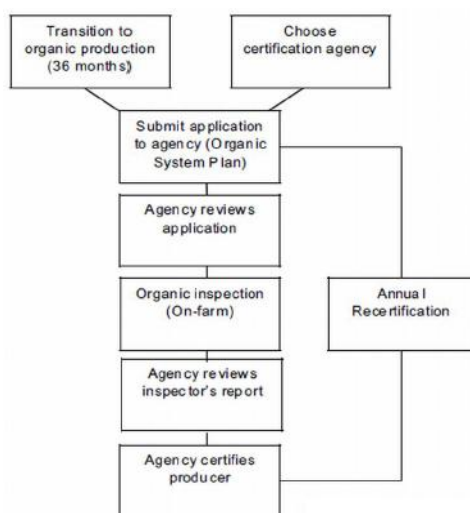


Fig. Flow Chart of the Process of Organic Certification (Swisher and Koenig, 2005.)

Once an operation is certified, its organic status never expires unless it is suspended, revoked, or surrendered. The operation must be visually inspected and the organic system plan recertified annually by the agency. The cost of certification varies from agency to agency and growers should explore different accredited certifiers to determine which one fits their needs. The producer typically pays for the inspector's travel costs to the farm for inspection.

### Applying the organic label

The use of the organic seal is not a requirement, but producers are obligated to identify their certifying agency with a written statement on processed products. There are a number of labels that can be used to designate organic products depending on the amount of organic agricultural ingredients and approved nonagricultural ingredients a processed product contains. For single-ingredient agricultural products including raw fruits and vegetables, the product claim is clear: if it is certified and labeled as organic, then it is 100% organic.

However, when products contain multiple ingredients, product labeling may be confusing for the consumer.

There are four general categories of marketing claims:

**100 % Organic** 100% of ingredients are certified organic, excluding salt and water.

**Certified Organic** 95% of ingredients are certified organic, excluding salt and water.

**Made with organic ingredients;** At least 70% of ingredients are certified organic, excluding salt and water.

**No Label Claims** Less than 70% of ingredients are certified organic.

### The organic system plan

In organic production, management strategies are selected to restore, maintain, and enhance ecological harmony among the components of the farming system. A common misconception is that organic farming merely involves the substitution of organic for mineral fertilizers and biological and cultural pest controls for synthetic pesticides. However, the misapplication of organic materials or pest control strategies will effectively disrupt the function of ecological and biological cycles and may lead to detrimental outcomes (Lampkin, 1990).

It is important to note that certifiers cannot provide consultation services to a producer. They cannot consult on matters of pest control strategies or rotations, nor suggest particular products, nor recommend a crop consultant.

These things would constitute a conflict of interest. Producers are required to design and subscribe to a soil management plan to ensure that they are managing plant and animal materials in a manner that does not contribute to the contamination of crops, soil, or water by crop nutrients, pathogens, heavy metals, or residues of prohibited substances. Rotation, tillage, irrigation, fertility management, and a soil and plant nutrient monitoring program are all factors that affect soil and water quality and should be included in the plan. The *pest management plan* provides producers with a road map to manage pests through mechanical, physical and cultural control methods. Approved nonsynthetic biological, botanical, or mineral inputs may be used to manage pests only if preventative methods fail to provide sufficient control.



**In order to certify your farm as organic you must follow the steps presented below:**

1. A description of the record-keeping protocols.
2. A plan of all inputs to be used, including documentation of their composition, source, and the location and date used.
3. The monitoring practices to verify the plan is effectively implemented.
4. A description of practices and physical barriers used to prevent commingling of organic and conventional products on farms with split production. Also, to prevent organic products from contamination with prohibited substances.
5. An accurate map of the farm including permanent structures, field boundaries, noncrop areas and hydrologic features such as wells, irrigation ditches and ponds.
6. Field histories documenting production methods (conventional, transitional, organic), crops, cover crops, all inputs, and field sizes or production area (if greenhouse or beds).

For operations with split production systems (organic and non-organic), the plan must define adequate buffer zones (physical structures or natural features) to prevent the possibility of unintended contact with a prohibited substance; establish protocols to prevent commingling of unpackaged organic and non-organic products; and outline an equipment cleaning protocol for shared equipment.

### **Approved amendments**

Every country has a National List of Allowed and Prohibited Substances (commonly referred to as the "National List") who specifies the inputs that are allowed for use in organic production, handling, and processing.

The term *synthetic* is defined as "any substance that is formulated or manufactured by a chemical process." Substances that are created as the "result of naturally occurring biological processes" are referred to as non-synthetic or *natural*. All substances approved by the National Organic Program must be used as indicated on the National List which is organized in specific use categories such as an insect control or a soil amendment.

In some instances, a substance or material may be approved for use in one application (sanitation), but prohibited in another (soil amendment).

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