**Hortus USA Corp.**
**Written by Joel Kroin, President**
support@hortus.com http://rootinghormones.com
Download: http://rootinghormones.com/Optimizing/Optimizing.pdf
Published: June 2026
Index and Table of Contents are on the last pages

# OPTIMIZING PLANT PRODUCTION THROUGH SCIENCE:
**Applied Plant Propagation Methods and Technology**

The modern grower is encouraged to go beyond older methods and use this article to understand the underlying physiology of plant growth and the full range of available methods.

Success in plant propagation relies on selecting methods and materials grounded in the science of plant physiology and histology, rather than tradition or rote habit. To achieve consistent results, growers must understand the biological mechanisms, specifically how rooting hormones enter the plant, translocate through the vascular system, and accumulate to trigger root initiation. By applying biological principles, propagators can move beyond trial and error, optimizing facility usage, reducing labor, and increasing overall cost-effectiveness.

Over the past three decades, the field of plant propagation has undergone major improvements driven by the availability of aqueous IBA rooting solutions, specifically through the technological innovation of Hortus IBA Water Soluble Salts. This unique formulation allows commercial growers to utilize innovative, labor-saving application techniques, including the foliar Spray Drip Down and Total Immerse methods, as well as the basal Quick Dip and Long Soak methods. Furthermore, its uses extend far beyond standard stem cuttings to include division, grafting, layering, stenting, tissue culture, stock plant improvement, and transplant root regeneration.

## SECTION 1 HISTORY OF PLANT PROPAGATION & AUXINS

Auxins are a class of plant hormones that serve as primary signaling molecules for regulating growth and development, specifically stimulating cell division and root formation. The methods used by plant growers are not arbitrary; they are the result of long-term botanical research.

(Terminology Note: "Rooting hormone" and the scientific term "auxin" are used interchangeably to describe the specific hormones that trigger root initiation.)

### Pre-Modern Plant Propagation
Relying on observation and seasonal timing rather than chemicals, early growers utilized natural growth stimulants found in juvenile shoots and grain seeds. Techniques evolved from prehistoric seed selection to ancient layering and medieval grafting. Lacking modern infrastructure, they created microclimates using walled gardens and glass jars, unknowingly applying fundamental principles of plant physiology.

### Early Glasshouses (18th-19th Century)
Using glass houses, growers maintained near 100% humidity to prevent desiccation while utilizing "bottom heat" systems to encourage callus formation before leaves dehydrated. However, if a cutting did not naturally produce enough internal rooting hormone to respond to the warm soil, it simply would not root.

### Traditional Plant Propagation Methods (1880-1930s)
Before the identification of auxins, propagation was a craft defined by observation and environmental manipulation rather than internal chemistry. Growers relied heavily on seeds, division, bulbs, tubors, grafting, and layering. Success with unrooted stem cuttings was rare and largely restricted to easy-to-root species that naturally possessed high levels of endogenous auxin.

**The Concept of Hormones (1880):** The scientific understanding of this internal chemistry began with Charles Darwin. In his work The Power of Movement in Plants (1880), Darwin described experiments on phototropism (plants bending toward light). He observed that when the tip of a seedling was covered, the plant failed to bend. He accurately hypothesized that a "transmissible influence" was produced in the shoot tip and moved down the stem to direct growth.

**Proof of a Chemical Signal (1913):** Building on Darwin's hypothesis, Peter Boysen-Jensen proved that this "influence" was actually a physical substance moving through the plant. In a groundbreaking experiment, he cut off the tips of seedlings and placed a block of gelatin between the severed tip and the base. Because the signal successfully passed through the gelatin causing the stem to bend, he confirmed that the influence was a diffusible chemical signal, water-soluble substance capable of natural processes.

**Chemical Identification (1934-1935)**

In 1934, Kenneth Thimann and Frits Went identified the plant's natural root-forming hormone as Indole-3-acetic acid (IAA). Once identified, they analyzed its exact molecular structure. Hypothesizing that the plant's rooting response was triggered by this specific chemical shape, scientists began looking for structurally similar chemical analogs. Because multiple synthetic compounds were eventually found to mimic the natural rooting response, "auxin" became the official classification for this entire family of structurally related plant growth regulators.

**The Natural Auxin Replacement (1930s-1940s)**

While IAA was identified as the natural rooting hormone, its instability and difficult extraction made it commercially unviable. A practical solution emerged after chemists Jackson and Manske synthesized Indole-3-butyric acid (IBA) in 1930. They provided samples to Percy Zimmerman and Albert Hitchcock at the Boyce Thompson Institute, who discovered in 1935 that synthetic IBA was a remarkably stable and effective alternative. Unlike IAA, IBA remained intact in plant tissue long enough to consistently induce rooting, rapidly establishing it as the standard for commercial plant propagation.

**The Rise of General Foliar Applications (1950s-1970s)**

While plant propagators remained focused exclusively on treating the root zone, general agriculture began successfully applying liquids directly to leaves. In the early 1950s, researchers utilizing radioactive isotopes conclusively proved that plant foliage could actively absorb and transport liquid fertilizers. Shortly thereafter, the agricultural industry began spraying other synthetic Plant Growth Regulators (PGRs) over crop canopies to manage fruit ripening and flowering. This established the foundational proof that foliar absorption was highly effective, setting the conceptual stage for future plant science breakthroughs.

**The Era of Limitations in Propagation (1950s-1980s)**

Despite the agricultural success of foliar sprays and the early availability of synthetic IBA, plant propagation methods remained severely restricted. For decades, propagators taking cuttings were limited exclusively to basal dips and dry powders due to two massive roadblocks:

**The Chemical Barrier:** Pure IBA is only slightly soluble in water. Historically, the only way to create a liquid rooting hormone was to dissolve it in active solvents or alcohol. If applied to foliage, these solvents severely burn or kill tender leaves. (Note: Growers are still advised to avoid any commercial rooting products containing active solvents for this exact reason). Because the modern, safe aqueous solutions we use today did not yet exist, the foliage simply could not survive the chemical delivery vehicle. K-IBA, the aqueous (water-soluble) salt of IBA, is costly and not widely available.

**The Biological Barrier:** Because of this chemical limitation, the concept of applying rooting hormones to the foliage was not trusted or commercially adopted by the greenhouse industry. Propagators operated under the strict assumption that hormones had to be applied directly to the physical basal wound, relying on the slightly soluble dry IBA powder to slowly dissolve and release the hormone into the wet media. The industry lacked the physiological blueprints that Dr. Frederick Davies and Dr. Jerry Cohen would later provide. The scientific reality that leaves could absorb solutions through open cuticles and stomata and actively translocate them downward via Polar Auxin Transport (Went and Thimann), or that the basal tissue dynamically regulates these hormones within a "Metabolic

Reservoir" (Dr. Cohen's research explained in the Technical section), simply did not exist in commercial production until the late 1980s.

**Contemporary Use of Physiology (1980s-Present)**
The modern era of foliar application of auxin was fundamentally shaped by the pioneering work of Dutch researcher Kees Eigenraam at Rhizopon bv. In the late 1980s, working in the Netherlands, Eigenraam recognized the severe labor and chemical limitations of traditional basal dips and rooting powders. He utilized aqueous (water-based) IBA rooting solutions made from limited use Rhizopon AA Water Soluble Tablets. Eigenraam conducted commercial trials on chrysanthemum cuttings, proving that water-soluble auxins could be safely and effectively applied directly to the foliage of unrooted cuttings without causing phytotoxicity. This breakthrough successfully eliminated the need for labor-intensive manual treatments.

**Introduction & Standardization (1990s)**
Building upon Eigenraam's extensive European trials, Joel Kroin of Hortus USA partnered with him to bring these innovative protocols and products to the U.S. market in 1990. Kroin officially coined the terms for the "Spray Drip Down" and "Total Immerse" methods with the introduction of Hortus IBA Water Soluble Salts. This breakthrough provided growers with a single, highly versatile product formulated for all propagation methods, both foliar (Spray Drip Down, Total Immerse) and basal (Quick Dip, Long Soak). Together, Eigenraam's chemical breakthroughs and Kroin's operational protocols successfully shifted the propagation industry away from exclusively manual basal dipping and into the highly efficient era of foliar combined with basal application physiology.

**THE MODERN PHYSIOLOGICAL APPROACH**
Building upon the anatomical research of Dr. Frederick Davies, modern foliar techniques, such as the Spray Drip Down and Total Immerse methods, utilize the leaf cuticles and stomata as natural entry points, allowing growers to safely and effectively treat the entire cutting. Furthermore, integrating the biochemical research of Dr. Jerry Cohen, today's protocols treat the plant as a dynamic living system. By understanding how the vascular system naturally transports auxins and how the basal wound regulates its internal metabolic reservoir, growers can utilize multiple foliar applications to safely recharge the IBA reservoir. This technique prevents the rooting process from stalling in difficult-to-root crops, a critical operational capability that was completely impossible with traditional basal-only methods.

While the shift from traditional basal dipping to foliar application is a major advancement, both methods effectively drive root formation and can be co-used in the same facility using a single product. The key is balancing these techniques to optimize the specific labor, workflow, and cost requirements. By understanding internal plant systems, propagators can replace outdated methods with precision science. The following sections detail how to use Hortus IBA Water Soluble Salts to apply these principles, maximizing efficiency, reducing labor, and consistently achieving high-quality roots across all propagation methods.

**Understanding the historical evolution of auxin from unstable natural compounds to modern solutions sets the stage for practical application. However, before any chemical solutions are applied, successful propagation begins with the biological source. Section 2 explores how managing the health and physiological age of the mother stock plant fundamentally dictates future rooting success.**

## SECTION 2 THE STOCK PLANT

The biological quality of stock plants fundamentally dictates propagation success across all methods of vegetative reproduction. Whether the grower is propagating plant parts through standard cuttings, division, bulbs, tubors, grafting, or layering, the harvested tissue must possess vital carbohydrate reserves to survive the energy-intensive rooting process. Therefore, mother plants must be maintained in a nutritionally vigorous, actively vegetative, and disease-free state. Vigorous vegetative growth is not always desirable, for example, dormant hardwood cuttings, or parts used for bench grafting.

## PHASES OF DEVELOPMENT AND ZONATION

Rooting potential is not static; it fluctuates based on internal chemistry and the physiological age of the specific tissue being harvested. Physiological age is not uniform across a single plant, a biological phenomenon known as Zonation:

**The "Cone of Juvenility" (Basal Zone):** This is a highly sensitive, vegetative area at the base of the stock plant. Because this tissue is biologically primed for rooting and lacks mature bark, it requires lower concentrations of auxin to stimulate adventitious root formation (ARF) using Hortus IBA Water Soluble Salts via foliar methods (Spray Drip Down or Total Immerse). Harvesting from this basal zone allows growers to safely bypass high-concentration basal dips. (The biological mechanisms behind this are discussed in the TECHNOLOGY, Section 11).

**The Mature Canopy (Upper Zone):** As the plant grows vertically and the distance from the root system increases, the tissue becomes physiologically mature. Consequently, cuttings taken from the top of an older stock plant are significantly more difficult to root.
(The specific cellular barriers of mature wood are discussed in the CUTTINGS, Section 3).

**Topophysis (The Memory of Position):**

Distinct from Zonation (age), Topophysis refers to the "memory of position." The specific orientation of the cutting on the stock plant dictates the physical growth habit of the new clone:

**Vertical Selection (Orthotropic Growth):** Cuttings taken from top or vertical leaders exhibit orthotropic growth, meaning they will continue to grow upward and produce a symmetrical plant. While these shoots have the best shape, they may be physiologically mature and harder to root.

**Lateral Selection (Plagiotropic Growth):** Cuttings taken from side or lateral branches often exhibit plagiotropic growth. These cuttings retain the horizontal habit of the side branch, growing sideways rather than vertically. This is particularly pronounced in conifers; for example, a side branch cutting from a Yew or Norfolk Island Pine may result in a prostrate, vine-like plant that never develops a central leader.

## STOCK PLANT MANAGEMENT & TREATMENTS

Cutting efficiency depends entirely on the uniformity of the starting material. Annuals, perennials, and woody stock plants often exhibit irregular growth habits, making it difficult to harvest large batches of consistent cuttings. Professional growers can utilize foliar Spray Drip Down IBA solutions directly on the mother plant to manage health and maximize yield prior to taking cuttings.

**General Maintenance (Spray Drip Down):**

To regenerate the root system and prevent stagnation in established plants, growers can spray a low IBA trial rate, depending upon variety, monthly during the active growing season.

**Pre-Harvest (Chemical Conditioning):**

To maximize uniformity and speed up rooting, growers can chemically condition carefully selected stems prior to harvest. Spraying IBA solutions at the propagation trial rate 1 to 2 weeks before harvesting pre-loads the stems and leaves with the necessary hormonal signal. Because the cuttings still have the hydraulic support of the mother root system during application, this technique drastically accelerates subsequent root formation once the cuttings are severed.

**Flush Management (Stimulation):**

To overcome irregular growth, stock plants are treated to generate a synchronized flush of vegetative growth. Pinching the plants (removing their terminal tips) stimulates the simultaneous development of lateral shoots. Spray Drip Down solutions help to synchronize the growth cycle and load the tissue with auxin. This ensures the resulting shoots are identical in both physiological age and physical size, allowing for the efficient, one-time harvest of a high volume of uniform cuttings.

**Hedging, Stooling and Growth Improvement (Maintaining Juvenility):**

**Hedging:** Involves maintaining stock plants as sheared hedges. The goal is to prevent the plants from reaching sexual maturity (flowering) and to encourage continuous, vegetative shoot production.

**Stooling:** Involves pruning back the stock plants close to the ground (the stool). This forces vigorous, juvenile shoots to emerge directly from the root-shoot junction, the "Cone of Juvenility." This technique ensures the new growth possesses the highest possible rooting potential.

**Once the stock plant is optimally conditioned, the propagator must carefully harvest the tissue. Section 3 outlines the specific environmental controls, seasonal timing, and physical preparation required to transform a raw stem or other propagation part into a viable cutting, or for uses in layering, grafting, or division.**

## SECTION 3 THE CUTTINGS:

**Cuttings Are Only One Type of Plant Part Used for Propagation:** Plant parts, such as stems, leaves, or roots (detailed in Section 7), are used for various alternative propagation methods, including layering, grafting, stenting, division, and tissue culture. However, propagation by cuttings remains the most used.

Cuttings produce true genetic clones, ensuring highly predictable and uniform growth habits, quality, and disease resistance. Success hinges on balancing biological efficacy with operational efficiency by matching the application method to the plant's specific physiological state, enabling growers to effectively tailor rooting applications to meet any crop's exact requirements.

**THE COHEN AND DAVIES RESEARCH: Integrating Biology and Chemistry**
A successful propagation strategy integrates stock plant health with precise cutting selection based on physiological age. By applying the research of Dr. Davies (histology and transport) and Dr. Cohen (chemical metabolic mechanisms), propagators can perfectly match specific rooting treatments to the plant's exact internal developmental state.

**HISTOLOGICAL PHASES: Juvenility vs. Maturity**
Dr. Davies' research establishes that a cutting's developmental stage directly dictates the required propagation method and chemical concentration. Because juvenile tissue (such as the Cone of Juvenility) is physiologically primed for rooting with high auxin sensitivity, growers can utilize labor-saving foliar applications with low concentrations of aqueous Hortus IBA Water Soluble Salts solutions.

**BARRIERS TO ROOT INITIATION (Mature Tissue):**
Conversely, as plants transition to the mature reproductive phase, their natural rooting potential severely decreases. While mature tissues may show slightly reduced auxin uptake due to thicker, waxier cuticles, Dr. Davies notes that physical barriers (like bark or tissue restriction) are rarely the primary cause of rooting failure. The true limitation in mature cuttings is a loss of internal physiological and ontogenetic competence. As the tissue matures, it undergoes epigenetic changes (genes being turned off) that prevent the cells from responding to auxin. To overcome this epigenetic predisposition and successfully trigger cellular dedifferentiation, propagators must shift methods entirely, utilizing high-concentration Basal Quick Dips to chemically force massive amounts of rooting hormone into the tissue. (Root formation solutions for mature tissue are discussed in PROFESSIONAL GROWER GUIDANCE & OPERATIONS, Section 11).

**ENTRY, TRANSPORT, AND THE ROOTING ENGINE**
For juvenile or actively growing cuttings, foliar applications effectively utilize the plant's natural vascular mechanisms to deliver rooting hormones. (The advanced biochemical concepts of the "Metabolic Reservoir" and "Polar Auxin Transport" are defined in detail in Section 11).

**THE DUAL-PATHWAY OF FOLIAR ABSORPTION**
To succeed, the exogenous rooting hormone must transition from the external leaf surface into the internal vascular system. Modern plant physiology recognizes this foliar uptake as a sequential, two-step process:
**Step 1: Surface Penetration** (The Microscopic Landscape)

The rooting hormone must first breach the exterior of the leaf. This initial uptake utilizes a "dual-pathway" model, relying on both the **cuticular pathway** (continuous diffusion) and the **stomatal pathway** (hydraulic activation). Understanding how aqueous IBA solutions interact with these two distinct surface structures is essential for successful absorption.

**Step 2: Internal Vascular Loading** (Cellular Hurdles)

Once inside the leaf through either the cuticular or stomatal pathway, the physical journey is not complete. The hormone must then successfully overcome internal cellular hurdles to move from the localized leaf tissue into the main stem for downward transport.

**THE CUTICULAR PATHWAY (Continuous Diffusion)**

Structure and appearance: The cuticle is a waxy, non-cellular protective membrane covering the outer epidermis of the leaf. It is naturally designed to prevent moisture loss and pathogen entry. To the naked eye, it appears as the glossy, shiny sheen on the top of a leaf (such as on a Ficus or Holly). Microscopically, it is not made of individual cells; rather, it acts as a continuous, solid blanket of secreted polymers (cutin) and waxes laid over the epidermal cells below, much like a layer of waterproof stucco over a brick wall.

**The Pathway:**

Foundational research, notably by M.J. Bukovac, established that the cuticle is not a completely solid barrier, but rather a semi-permeable membrane. Aqueous IBA solutions successfully diffuse across this waxy blanket through microscopic polar domains.

**Ambient Needs:**

This cuticular diffusion relies heavily on the propagation environment. Uptake is significantly enhanced when the greenhouse air is warm (which plasticizes the waxes) and the cuticle remains highly hydrated by ambient misting.

**Internal Transport and Limitations:**

The cuticle serves as the foundational, continuous gateway for initial auxin uptake. This is especially critical immediately after a cutting is severed, when severe water stress causes other pathways to close. However, its thickness is a major limiting factor. In mature, heavily lignified leaves, this waxy armor becomes too thick for weak solutions to penetrate. Furthermore, once the IBA diffuses through the cuticle, it faces a significant internal hurdle: it must successfully navigate through the dense epidermal cells to reach the internal mesophyll tissue before it can be loaded into the vascular system.

**THE STOMATAL PATHWAY (Hydraulic Activation**)

Structure and appearance: Unlike the passive, non-cellular cuticle, stomata (singular: stomate) are highly active, living microscopic pores built directly into the leaf's epidermis. Under a microscope, a stomate resembles a pair of lips consisting of two specialized, balloon-like "guard cells" surrounding a central opening. These guard cells act as dynamic hydraulic valves. When the plant is well-hydrated, they swell and pull the central pore open; under water stress, they deflate and clamp the pore tightly shut. Directly beneath this pore lies the sub-stomatal cavity, a vital internal air space surrounded by loosely packed mesophyll cells.

**The Pathway:**

Concurrently with cuticular diffusion, these open pores serve as a dynamic, high-capacity entry point. While surface tension prevents bulk liquid from flooding the pores, under proper conditions, a continuous liquid film forms along the pore walls, a process known as the Hydraulic Activation of Stomata (HAS). This film acts as a liquid bridge, drawing the aqueous IBA solution down past the guard cells and directly into the internal air spaces of the leaf.

**Ambient Needs:**

This pathway requires strict environmental control. The cutting must be fully hydrated and turgid, and the propagation bench must maintain very high ambient humidity and a low vapor pressure deficit (VPD).

**Internal Transport and Limitations:**

The primary internal limitation is the cutting's own biological stress response. When a cutting is severed, it experiences an immediate water deficit. This stress triggers Abscisic acid (ABA) signaling, which forces the guard cells to clamp the stomata shut to conserve moisture, effectively blocking this entry pathway. However, when environmental conditions (like a commercial misting bench) allow the stomata to remain open, the aqueous IBA is drawn fully into the sub-stomatal cavity. Once inside this spacious air pocket, the solution makes direct contact with the massive surface area of the internal mesophyll cells. This grants the rooting hormone unimpeded access for rapid cellular absorption and immediate translocation into the vascular system, completely bypassing the thick epidermal wall.

**PHLOEM LOADING AND STEM TRANSPORT (The Polar Route)**

The critical biological challenge of foliar application is moving the IBA from the localized leaf tissue into the main stem. Regardless of whether the IBA enters through slow cuticular diffusion or rapid stomatal activation, it ultimately arrives in the leaf mesophyll. From here, the exogenous IBA is absorbed into the plant's phloem (the living vascular tissue responsible for transporting soluble organic compounds) and travels alongside natural photosynthates.

Once successfully loaded into the vascular bundles of the leaf, the hormone joins the plant's natural transport stream. Driven by Polar Auxin Transport (PAT), the plant actively ferries the hormone out of the leaf petiole and basipetally (downward) through the main stem.

**Physiological Sink and Metabolic Reservoir:**
This downward flow stops abruptly at the severed basal wound, creating a highly concentrated "Physiological Sink". Here, Dr. Cohen's mechanism takes over: the plant safely stores this accumulated hormone in a stable metabolic reservoir.

**Root Initiation:**
This localized chemical pressure triggers Peroxisomal ß-Oxidation (conversion of IBA to IAA). This specific enzymatic process provides a sustained, slow-release signal that stimulates basal stem cells to dedifferentiate into actual root primordia.

**CUTTING ENVIRONMENT AND PREPARATION**
The success of propagation depends on where the plant is storing its energy regarding seasonal carbohydrate partitioning. Collection timing must align with the plant's natural hormonal cycles. Depending upon the ambient climate, material should be taken in the early morning, or at another time when the plant is fully turgid, minimizing water deficit stress.

- **Active Season (Spring/Summer):** Energy is moving to new shoot tips. Herbaceous, semi-hardwood and softwood cuttings are taken during active growth phases.
- **Dormant Season (Winter), and Hardwood:** Energy is kept in the roots and crown.

**SELECTION AND PHYSICAL PREPARATION**
Success begins with the selection of high-quality material. Always use healthy stock plants that are free from disease and viruses. The best dormant cuttings are taken from the current season's growth (one year old wood, mature and woody), generally pencil-thick or slightly larger depending on the species. Do not use soft, pithy wood or excessively thick water sprouts, as these tissues often rot or fail to produce roots.
Once selected, physical preparation is required to optimize the energy balance:

- **Polarity (Keeping it Right-Side Up):** Proper cutting preparation requires the strict maintenance of polarity, meaning the cutting must be planted in the exact same upward direction it grew on the mother plant. If stuck into the soil upside down, it will not grow. Because bare stem sections can look identical on both ends, propagators use a specific cutting technique to create a visual guide:
  - **Making the Cuts:** For the **bottom (basal) cut**, make a straight, flat cut just below the bottom node. This is the end that goes down into the soil. For the **top cut**, make an angled, slanting cut just above the top node. This simple visual distinction guarantees the cutting is never accidentally stuck upside down in the propagation bed. Additionally, the slanted top cut allows overhead water to safely shed off the stem, significantly reducing the risk of rot.
- **Leaf Preparation & Water Control:** Remove leaves from the lower third of the cutting to prevent rot. For large-leaf species, cut the remaining leaves in half using sharp shears. A large leaf area acts as a massive pump for water loss (transpiration); reducing surface area ensures the cutting remains turgid, an absolute prerequisite for metabolic activity.
- **Flower Bud Removal (Energy Sinks)**: Flowers and fruits are dominant reproductive sinks that actively import carbohydrates. If left on a cutting, they starve the basal wound where new roots need to form. Always remove flower buds before sticking to redirect energy to root initiation.
- **Node Cuts:** Make the basal cut just below a node, as this area is rich in cellular activity and root traces. Inter-nodal cuts are generally reserved for hollow-stemmed plants to prevent rot.

**Wounding:** For difficult-to-root woody species, removing a thin, 1-inch slice of bark at the base exposes the cambium. This overcomes the physical barrier of the sclerenchyma ring and increases the surface area for water and auxin absorption.

## CLASSIFICATION OF CUTTINGS & SEASONAL WINDOWS

Propagation material is classified based on the specific plant part selected (e.g., stem, leaf, or root) and the physiological maturity of the wood at the time of harvest. Rooting potential is directly tied to a plant's seasonal cambial activity. Growers must align their application methods with the plant's biological window to ensure the plant can actively process it.

### Episodic Growth and Multiple Propagation Windows

While many woody ornamentals produce only a single flush of new growth in the spring, numerous species exhibit a biological trait known as "episodic growth" or recurrent flushing. As noted by Dr. Davies, these specific woody plants go through two to three distinct growth flushes in a single year. Operationally, this means a propagator is not limited to a single annual harvest.

By carefully managing the greenhouse environment and stock plant nutrition, it is possible to harvest two to three distinct sets of highly rootable softwood or semi-hardwood cuttings in a single season. Once the initial spring flush hardens off, the plant will push a secondary summer or even tertiary fall flush. Classic examples of this recurrent growth include broadleaf evergreens (such as Ilex and Ficus pumila), tropicals (such as Citrus), and certain deciduous shrubs (such as Rosa). By applying foliar Spray Drip Down rooting treatments to these successive flushes, growers can safely and efficiently multiply their annual cutting yield from the exact same stock block.

### Leafy & Active Stock (Spring/Softwood Cuttings)

Target plants are Annuals, Perennials, Herbs, Softwood Cuttings, Pot Roses, and any active cutting with functioning leaves. In the spring, the cambium is highly active and metabolizing rapidly, but these soft tissues are prone to desiccation. These cuttings possess permeable cuticles, open stomata, and an active vascular system. These methods utilize the plant's natural transport system to load the metabolic reservoir gently and uniformly. To safely sustain the rooting signal without burning tender foliage, growers should use low ppm IBA trial rates with the Spray Drip Down or Total Immerse methods. Because the spray must envelop the foliage to ensure contact with the cuticle and stomata (which may also occur on the upper leaf surface depending on variety), these methods offer the highest sanitation standards. Foliar Methods (Spray Drip Down or Total Immerse) are superior for synchronized flush crops where all cuttings are at the same developmental stage, allowing treatment of the entire crop simultaneously with a single concentration trial rate.

**Herbaceous:** Taken from soft, non-woody plants (e.g., geraniums, coleus, annuals, perennials, tropicals). These allow for rapid root initiation due to active growth and are highly responsive to foliar applications.

**Softwood:** Taken from new, succulent growth of woody plants early in the growing season (spring and early summer). These possess high rooting potential but are susceptible to desiccation and often require strict humidity control or mist to prevent wilting.

**Leaf Cuttings**: Used for plants with fleshy leaves (e.g., Begonia, African Violet) where the leaf blade or petiole is used. New roots and shoots form at the base or from the primary veins.

**Root Cuttings:** Used for species with fleshy roots or those that naturally produce suckers (e.g., Phlox, Anemone, Oriental Poppy, and Rubus species like raspberries). Sections of roots are typically harvested in late winter or early spring while the plant is still fully dormant.

### Woody & Lignified Stock (Mid-to-Late Summer / Semi-Hardwood)

Mid-to-late summer is the optimal, balanced window for many woody ornamentals as stems mature, harden, and build carbohydrate reserves. Target plants are woody ornamentals, conifers, and difficult-to-root species with lignified stems. The cambium remains active enough to respond well to labeled IBA trial rates using any of the Hortus IBA application methods. However, these stems may have bark that block low-concentration sprays, and stomata may be fewer and cuticles thicker. A high concentration IBA solution is applied to the cut base to force the IBA into the cell membranes of the cut surface and epidermis, bypassing physical barriers to trigger root formation. Basal Quick Dip is preferred for variable crops where cuttings differ in hardness, allowing the propagator to sort the cuttings by maturity and adjust the concentration or dip duration according to the specific needs of each group.

- **Semi-Hardwood (Green-Wood):** Taken from partially mature wood from the current season's growth (mid-summer to early fall), after the wood has partially firmed. They have firmer wood and higher carbohydrate reserves than softwood, making them slightly more resilient.
- **Medial (Mid-stem):** Taken from the middle section, below the soft tip but above old wood. Rooting success is variable and species-dependent. Intermediate levels of hormones and carbohydrates may require higher exogenous applied IBA concentrations to initiate roots. Treated by Total Immerse or Basal Quick Dip.
- **Basal (Old Wood):** Taken from the older, lignified base of the stem. Basal portions can exhibit enhanced rooting due to retained juvenile characteristics (if near the cone of juvenility). Crucially, the tissue possesses a suberin bark barrier, requiring a Basal Quick Dip at high IBA concentrations.

**Dormant & Leafless Stock (Late Fall to Winter / Hardwood)**

Propagation of leafless, dormant hardwood cuttings is a primary method for producing deciduous shrubs, trees, roses, and grape rootstocks. Processing is typically performed during the dormant season, ranging from late fall after leaf drop to late winter. The plant enters dormancy, depleting natural auxin and heavily lignifying the woody tissue. The ideal window is often mid-winter when the plant is fully dormant, allowing cuttings to be harvested, treated, and stored before spring planting. Cuttings should not be taken once buds have begun to swell in early spring, as this metabolic activity depletes the energy reserves specifically needed for rooting.

- **Physiology:** This method utilizes the plant's stored carbohydrate energy reserves accumulated during the previous growing season. Because vascular flow has stopped and active leaves are absent, foliar IBA sprays are entirely ineffective. Because these cuttings are leafless, there are no stomata available for foliar uptake, and the plant's active transport system is dormant. The cutting must absorb the IBA solution slowly through the cut basal end via capillary action or simple diffusion. Additionally, applying bottom heat to the propagation media is often necessary to increase cambial activity and force the plant to process the IBA.
- **Methods:** Growers must switch to targeted basal applications, specifically the Basal Quick Dip or Basal Long Soak, at high ppm IBA trial rates. Basal Quick Dip: High concentration forces IBA into the cell membranes of the cut surface and epidermis. Basal Long Soak: Very low concentration slowly allows IBA into the cell membranes.
- **Rootstock**: Usually dormant, with no leaves and inactive transport. Treated by Basal Long Soak.

**With the cuttings properly prepped and categorized by their physiological hardness, it is time to prepare the chemical rooting hormone. Section 4 details the product specifications, mixing trial rates, and handling of the industry standard: Hortus IBA Water Soluble Salts.**

## SECTION 4 HORTUS IBA WATER SOLUBLE SALTS

**SPECIFICATIONS:**
**Purpose:** Used in plant propagation to stimulate root formation and improve overall plant growth.
**Form:** A water-soluble, dry white powder.
**Solution:** When dissolved in ordinary water, the powder produces potassium Indole-3-butyric acid (K-IBA) solutions, the safe, water-soluble salt form of IBA.
**Concentration:** Can be mixed to make aqueous IBA solutions in concentrations up to 100,000 ppm IBA.
**Storage:** Packaged in a resealable container for long-term storage, boasting an indefinite shelf life.
**Compliance:** US EPA-registered for use by plant growers.WPS ZERO Hr. Restricted Entry Interval-REI

**CONTENTS: Hortus IBA Water Soluble Salts**
20% Indole-3-butyric acid (IBA), Active Ingredient
80% Other Ingredients

**Technical Grade IBA Conversion:** Because Hortus IBA Water Soluble Salts contain 20% active IBA, growers and researchers utilizing academic data based on 100% technical grade IBA must adjust their measurements to obtain the same ppm IBA. If calculating based on technical IBA weight, multiply that weight by five (x5) to obtain the correct physical weight of Hortus IBA Water Soluble Salts.

**PREPARING AND MIXING THE IBA SOLUTION**
To prepare the aqueous rooting solution, follow these operational steps:
**Determine the Concentration:**
ppm IBA for the specific plant and propagation method by consulting the LABEL PLANT TRIAL RATES (Detailed in PROPAGATION METHODS, Section 5).
**Calculate the Weight:**
Once the target ppm IBA and total desired liquid volume are established, calculate the exact weight of dry Hortus IBA Water Soluble Salts needed.
This calculation can be performed using THE SOLUTION MIXING CHART (below) or the
**online calculator** at **http://rootinghormones.com/calculatesalts.htm.**
**Measure Accurately:**
It is critical to always measure the dry powder using an accurate scale; never measure by volume with scoops or spoons, as settling alters the powder's density and leads to highly inaccurate dosing.
**Mix in Water:**
Dissolve the weighed powder in ordinary water. Never use alcohol or chemical solvents to dissolve the powder. Use Warm Water at a comfortable hand-washing temperature. If air moisture has caused the powder to clump, a warmer water temperature will easily dissolve any lumps.

**STORAGE AND DISPOSAL**
**Dry Powder Storage:**
The dry powder has an indefinite shelf life. Store it in its original container with the cover tightly closed. The product does not require any special temperature controls. Keep the container covered to prevent moisture from causing lumps.

**Stock Solution Storage:**
Once dissolved in water, the IBA solution degrades by about five to eight percent per month at ambient room temperatures. To maximize keeping life, store dissolved solutions in a cool, dark place.

**Production Solutions and Disposal:**

**Spray Drip Down (Multi-Day Use):** Because the solution is sprayed once and never reused, there is no risk of cross-contamination. Unused solution remaining in the tank can be safely saved and used for subsequent production lots.

**Total Immerse, Quick Dip, and Long Soak (Single-Day Use):** Dipping plant material directly into the solution introduces organic matter and potential pathogens. To prevent cross contamination, it is best practice to dispose of the dipping solution at the end of the workday, or immediately when switching to a different plant lot.

**Use On-Line Mixing Chart: http://rootinghormones.com/calculatesalts.htm**

any ppm in grams, ounces > liters, ml, fl.ounce quart, gallon

**SOLUTION MIXING CHART for Hortus IBA Water Soluble Salts**

| ppm IBA | gms/liter water | gms/gallon water |
|---|---|---|
| 50 ppm IBA | 0.25 grams | 0.95 grams |
| 100 | 0.5 | 1.9 |
| 200 | 1.0 | 3.8 |
| 250 | 1.25 | 4.7 |
| 300 | 1.5 | 5.7 |
| 400 | 2.0 | 7.6 |
| 500 | 2.5 | 9.5 |
| 600 | 3.0 | 11.3 |
| 700 | 3.5 | 13.2 |
| 750 | 3.75 | 14.2 |
| 800 | 4.0 | 15 |
| 900 | 4.5 | 17 |
| 1000 | 5.0 | 19 |
| 1500 | 7.5 | 28.5 |
| 2000 | 10.0 | 38 |
| 2500 | 12.5 | 47 |
| 5000 | 25.0 | 95 |
| 10,000 | 50.0 | 190 |
| | | |
| Can be made up 100,000ppm | 500 | 1900 |

**With the chemical rooting solution properly prepared, it is time to apply the hormone to the cuttings. Section 5 provides the step-by-step operational protocols for both foliar and basal application methods.**

## SECTION 5 PROPAGATION METHODS: from Cuttings and Other Uses
**Foliar Spray Drip Down and Total Immerse, Basal Quick Dip and Long Soak**

## SPRAY DRIP DOWN METHOD

**Cutting Propagation:**

The Spray Drip Down method is a highly efficient foliar technique primarily used for standard propagation. Unrooted, leafy, actively growing herbaceous and woody plant cuttings are stuck directly into the media and uniformly sprayed with an aqueous IBA rooting solution until it drips. Because cuttings are treated in bulk after being stuck in the media, this offers the lowest possible labor costs.

**Alternative Vegetative Methods:**

Beyond standard cuttings, this highly versatile method also supports initial root formation across a variety of alternative vegetative propagation techniques. It is frequently utilized to stimulate roots during division, grafting, layering, stooling, and stenting, as well as on seed crops after germination.

Because the solution is sprayed directly onto the crop and never reused, there is zero risk of spreading pathogens. Unused solution remaining in the tank does not need to be discarded between production lots.

**MULTIPLE APPLICATIONS (Boosters & Broad Utility):**

The primary use is plant propagation from cuttings, then multiple Spray Drip Down applications safely "refill" the plant's internal auxin reservoir over time. Beyond initiating root formation, this sustained chemical pressure is utilized for broad crop management, including preventing physiological stalling in difficult-to-root crops, stock plant improvement, crop leveling, and transplant root regeneration. It is the only method used for secondary applications, regardless of the initial rooting method applied. (Discussed in MULTIPLE SPRAY DRIP DOWN APPLICATIONS, Section 6)

**The Physiological Mechanism:**

The aqueous IBA solution absorbs through the leaf cuticle and stomata and travels downward via Polar Auxin Transport to the basal wound. Like Total Immerse, this foliar uptake loads the plant's metabolic reservoir, providing a continuous, slow-release auxin supply that triggers rooting while completely avoiding harsh solvent burns on sensitive tissues.

**THE PROCEDURE: Spray Drip Down**

**Solutions:** Hortus IBA Water Soluble Salts

**Equipment:** Using hand-pump, backpack, or hydraulic boom sprayers, this highly efficient method treats large batches simultaneously to drastically reduce labor costs.

To ensure open stomata and prevent heat stress, treat turgid (non-wilted) cuttings early in the day. Turn off overhead misters and allow excess water to evaporate to avoid diluting the rooting solution. Stick the cuttings, spray the solution, allow it to dry completely on the leaves (approximately 45 minutes), and then turn the misters back on.

**STEPS**

1. **Trial Rates:** refer to the Label (copied below)
2. **Stick:** Turn off misters. Plant unrooted cuttings directly into the propagation media.
3. **Spray Drip Down:** Apply the solution uniformly over the foliage until it forms beads and drips down from the leaves.
4. **Dry:** Allow the solution to dry completely on the leaves (approximately 45 minutes) before turning the overhead misters back on.
5. **Solution Disposal:** The solution is sprayed once and never recirculated, there is no risk of cross contamination. Unused solution in the tank does not need to be discarded between production lots.

## TOTAL IMMERSE METHOD

**Cutting Propagation & Bulk Processing**:

The Total Immerse method is a highly efficient foliar technique primarily used to root cuttings from leafy, actively growing plant stock, such as annuals and perennials. In this process, unrooted cuttings are completely immersed in bulk into the aqueous IBA rooting solution using a simple basket and tub. After a brief draining period, the treated cuttings are immediately stuck into the propagation media. This method offers exceptionally low labor costs because many cuttings can be handled and treated simultaneously in a single basket. Complete immersion guarantees that every leaf and stem surface receives an even, consistent application of the rooting hormone.

**Specialized Cuttings & Tissue Culture:**

This method is perfectly suited for processing large, homogeneous plant lots where batch consistency is critical. Beyond standard herbaceous cuttings, it is highly versatile and ideal for large-leaf plants (like Hydrangea), trailing plants, and transitioning fragile tissue culture plantlets to soil.

**Application Flexibility:**

The Total Immerse method is versatile enough to be used as a primary, single application to initiate rooting, or as the foundational first step of a multiple-application protocol (by Spray Drip Down) to sustain the rooting signal over time.

Because dipping introduces organic matter and pathogens into the tank, these solutions are strictly for single-day use. To prevent cross-contamination, discard the solution at the end of the workday, or immediately when switching to a new plant variety.

**The Physiological Mechanism:**

Similar to the Spray Drip Down method, this complete foliar absorption effectively loads the plant's metabolic reservoir. This ensures a continuous, slow-release supply of auxin to safely trigger root primordia, leveraging the plant's natural transport systems without exposing sensitive tissue to damaging solvent burns.

**THE PROCEDURE: Total Immerse**

**Solutions:** Hortus IBA Water Soluble Salts

**Equipment:** Using dip tanks and strainer baskets, this highly efficient method allows growers to treat many cuttings simultaneously with minimal labor

To ensure stomata are open and cuticles are receptive, and avoid heat stress, treat only turgid (non-wilted) cuttings early in the day. Place the cuttings into a strainer basket, immerse them entirely into the solution for a few seconds, lift to drain the excess liquid, and immediately plant the treated cuttings into the propagation media.

**STEPS**

1. **Trial Rates:** refer to the Label (below)
2. **Total Immerse:** Place the cuttings into a strainer basket and dip them entirely into the rooting solution for a few seconds.
3. **Drain:** Lift the basket and allow the excess solution to drain off the cuttings.
4. **Stick:** Plant the treated cuttings immediately into the propagation media.
5. **Solution Disposal:** The dipping introduces organic matter and pathogens into the tank, so these solutions are strictly for single-day use. To prevent cross-contamination, discard the solution at the end of the workday, or immediately when switching to a new plant variety.

## BASAL QUICK DIP METHOD

**Cutting Propagation & Handling:**

In this process, the basal ends of unrooted cuttings are immersed into the IBA rooting solution for just a few seconds before being immediately stuck into the propagation media. Because cuttings must be physically handled individually or in small bundles, this method typically incurs higher labor costs than overhead foliar applications. (Note: For highly sensitive plant varieties that require basal treatment but cannot tolerate high chemical concentrations, growers should utilize the Basal Long Soak method instead).

Because dipping introduces organic matter and pathogens directly into the container, the cross-contamination risk is high, making these solutions strictly for single-day use. To prevent spreading disease, discard the solution at the end of the workday, or immediately when switching to a new plant variety.

**The Physiological Mechanism:**

Unlike foliar methods that utilize the plant's active transport system, the Quick Dip relies on high concentrations to physically overcome natural barriers. It creates a steep concentration gradient that forces the aqueous IBA solution directly into the vascular bundles and epidermal cracks. Crucially, because Hortus IBA Water Soluble Salts are entirely alcohol-free, growers can safely utilize these required high concentrations without the risk of basal burn (tissue necrosis) associated with commercial solvent-based dips.

**THE PROCEDURE: Basal Quick Dip**
**Solutions:** Hortus IBA Water Soluble Salts
**Equipment:** Using basic plastic or glass dipping containers, this method requires more manual handling (higher labor) but effectively treats many cuttings in a single day.

Prepare the rooting solution. This method requires higher ppm IBA trial rates than foliar applications to successfully penetrate the stem tissue. Immerse the basal end (approx. 1 inch) for just 3-5 seconds, drain, and immediately stick or store the cuttings.

**STEPS**

1. **Trial Rates:** refer to the Label (below)
2. **Dip Basal Ends:** Immerse the basal end of the cuttings approximately one inch deep into the solution for just a few seconds (typically 3-5 seconds). Do not soak.
3. **Drain:** Remove the cuttings and briefly allow the excess liquid to drain off.
4. **Stick:** Plant the treated cuttings into the propagation media immediately (or place them into cold storage if processing dormant winter cuttings).
5. **Solution Disposal:** The dipping introduces organic matter and pathogens directly into the container, so these solutions are strictly for single-day use. To prevent cross-contamination, discard the solution at the end of the workday, or immediately when switching to a new plant variety.

# BASAL LONG SOAK METHOD

**High-Value Propagation & Handling:**

Standardized in the 1940s, the Basal Long Soak is the primary method for rooting difficult to propagate crops. In this process, the basal ends of cuttings (which can be banded into bundles to treat many at once) are immersed in shallow trays or pans (at least 4 inches deep) of IBA rooting solution for 12 to 24 hours before sticking. Because of the extended processing time, dedicated undisturbed space, and manual handling required, this method is typically reserved for high-value crops where absolute precision and high success rates are required. It also provides the dual benefit of restoring vital turgor pressure to rehydrate dehydrated or cold-stored cuttings prior to sticking. This method is highly effective for treating recalcitrant woody species (such as rootstocks, Prunus, stem roses, and grapes) during both the dormant and active growing seasons. It is the ultimate delivery method for leafless, dormant stock where stomata are closed, foliar absorption is impossible, and phloem transport is inactive. It allows growers to safely deliver auxin to highly sensitive, recalcitrant plants that require deep penetration but cannot tolerate the high ppm IBA trial rates of a Quick Dip.

Because soaking introduces organic matter and pathogens into the tray, these solutions are strictly for single-use. To prevent cross-contamination, discard the remaining solution completely at the end of the production.

**The Physiological Mechanism (Hydraulic Mechanics):**

Relying entirely on hydraulic suction rather than active transport, natural moisture loss from the upper stem creates a vacuum that actively pulls the aqueous solution deep into the xylem. By using very low IBA concentrations over an extended period, this method safely delivers the necessary auxin load without the risk of tissue burn associated with high-concentration Quick Dips.

**THE PROCEDURE: Basal Long Soak**
**Solutions:** Hortus IBA Water Soluble Salts
**Equipment:** Using shallow trays or pans (at least 4 inches deep), this method requires a dedicated, undisturbed area. Cuttings (either active or dormant) can be banded into bundles to treat many at once.

Prepare the rooting solution. This method requires significantly lower ppm IBA trial rates than other applications. Place bundled cuttings into the tray so only the basal end is immersed 1-3 inches deep. Soak undisturbed for 12 to 24 hours in cool air with high humidity around the tops. Remove, drain excess liquid, and plant immediately or place into cold storage.

**STEPS**

1. **Trial Rates:** refer to the Label (below)
2. **Immerse:** Place the bundled cuttings into the tray so that only the basal end is immersed approximately 1-3 inches deep into the rooting solution. Do not submerge the entire cutting.
3. **Long Soak & Control:** Allow the cuttings to soak undisturbed for 12 to 24 hours. During this time, keep the ambient air cool and maintain high humidity around the tops of the cuttings to prevent them from drying out.
4. **Post-Treatment (Drain & Stick):** Remove the cuttings from the soak and allow the excess liquid to drain off. Plant them immediately into the propagation media, or place them into cold storage (if processing dormant winter cuttings).
5. **Solution Disposal:** The soaking introduces organic matter and pathogens into the tray, these solutions are strictly for single-use. To prevent cross-contamination, discard the remaining solution at the end of the production.

**ALTERNATIVE BASAL METHOD: DRY DIP (Rhizopon AA Powders)**
For growers in Europe and other regions where Hortus IBA Water Soluble Salts are not available, Rhizopon AA dry powder rooting products provide a proven alternative. Because pure IBA is relatively insoluble in water, when applied to the basal end and stuck in moist media, ambient moisture causes the IBA to slowly dissolve and enter the cutting. Juvenile herbaceous cuttings easily absorb this solution, while mature cuttings with hard walls may require physical wounding. As Dr. Davies established, IBA rate is dictated by tissue maturity. Operationally, powder rates do not directly correlate with solution rates. The relative scale (low to high) remains consistent for any variety. Once inside, the IBA undergoes the exact same temperature-dependent metabolic processes defined by Dr. Cohen. Any excess concentration is safely stored in the metabolic reservoir rather than being immediately converted to the active IAA needed for root formation. Dry Dip otherwise follows the ADVANTAGES OF THE BASAL QUICK DIP below.

**ADVANTAGES OF THE BASAL QUICK DIP:**

**The Historical Context and Perceived Control:**

Despite the massive labor saving benefits of modern foliar applications, the Basal Quick Dip remains a widely recognized and utilized propagation method. Much of this continued reliance is driven by historical tradition and operational inertia; many growers hesitate to abandon a technique that has worked for decades, and fear risking valuable commercial crops on unfamiliar foliar protocols. Additionally, hand dipping provides propagators with a strong sense of visual control. They can see the chemical being applied to the wound. Furthermore, because many facilities lack a deep understanding of internal plant physiology (such as Polar Auxin Transport), the concept of spraying leaves to root a stem seems counterintuitive.

Fortunately, for facilities utilizing many techniques, Hortus IBA Water Soluble Salts are used not only for the Basal Quick Dip but also for all other foliar and basal methods, functioning as one universal product. However, beyond tradition, the Basal Quick Dip continues to offer scientifically validated advantages that make it a highly effective and versatile tool in modern propagation.

**For Hardwood and Mature Tissue (High Trial Rates):**

Basal Quick Dip is the biological standard for rooting leafless, dormant, or heavily lignified mature cuttings. Because these cuttings possess a heavily suberized peridermis (bark) and lack active stomata, foliar sprays are entirely ineffective. The Quick Dip method allows growers to utilize extreme chemical pressure (at Trial Rates) to forcefully breach this mature structural armor and drive the hormone directly into the vascular cambium via diffusion. By restricting this massive dose strictly to the basal wound, propagators can overcome "mature recalcitrance" without causing toxic chemical burn to the upper canopy or apical buds.

**For Herbaceous and Sensitive Crops (Low Trial Rates):**

Conversely, low-concentration Basal Quick Dip (at Trial Rates) provide highly targeted biological advantages for sensitive, mixed, or stressed soft-tissue propagation. Restricting the hormone exclusively to the basal wound prevents auxin-induced epinasty (severe leaf twisting and cellular distortion) in sensitive apical meristems. Furthermore, it keeps the delicate upper canopy completely dry as it enters the propagation environment, reducing the risk of moisture-driven pathogens like Botrytis. Basal dipping also guarantees 100% uniform chemical dosing by physically bypassing the "umbrella effect" of overlapping broad leaves. Because it relies on capillary action rather than active cuticular and stomatal absorption, the hormone is successfully delivered even if a soft cutting has temporarily lost turgor pressure and wilted.

**Operational Advantages (Small-Scale & Micro-Batching):**

Operationally, this method is highly advantageous for small-scale growers and facilities processing diverse, small-batch production lots. It requires minimal capital investment and low setup costs, utilizing only basic dipping containers rather than expensive spray automation. This allows propagators to safely process mixed-taxa benches, seamlessly switching between highly precise, low-dose treatments and aggressive high-dose treatments side-by-side without compromising adjacent crops.

**ROOT REGENERATION AND TRANSPLANT RECOVERY**

Beyond initiating roots on standard cuttings, Spray Drip Down is a tool for ongoing crop management. Because it allows for safe, overhead interventions without physically uprooting or disturbing delicate new tissues, it is the ideal method for overall stock plant improvement, treating early seed crops, and managing transplant recovery. When rooted plantlets are moved into larger containers or out into the field, growers can stimulate robust root regeneration without risking physical damage to the root ball. Instead of manually handling delicate root systems, growers can apply Spray Drip Down solutions by utilizing the plant's natural polar transport system. The IBA is safely delivered downward to the root zone to trigger rapid, fibrous feeder root development (Discussed in the PLANT CARE AND CONTROL, Section 10).

**Treatment Trial Rates**:

For Treatments listed below, the trial rates for improving the root systems of transplants are generally consistent with, or slightly lower than, the standard propagation trial rates for the specific species:

**Herbaceous Plants:** about 50-100 ppm IBA

**Woody Cuttings:** about 500-1000 ppm IBA

**Container Treatments**:

To apply the IBA solution, it is possible to choose between two methods based on the container type:

**Total Immerse (For Bare-Root Plants or Liners):** The plant is removed from its original container, the entire plant is briefly dipped into the low-concentration IBA solution, and the plant is planted into the new container. This method is also used prior to winter storage.

**Spray Drip Down (For Large Plugs or Liners):** Ideal for situations where root dipping is impractical. After the units are transplanted and watered in to settle the soil, spray the foliage uniformly until the solution drips down. This foliar application can be performed immediately after transplanting or within a few days. Secondary Spray Drip Down applications can be made over several weeks if the crop requires additional physiological conditioning.

**Basal Long Soak Bare Root Treatments:**

The Basal Long Soak is a primary method for propagating and treating recalcitrant woody species, including rootstocks and stem roses. In this process, the basal ends or roots are immersed in a low concentration IBA rooting solution for 12 to 24 hours (utilizing the trial rates found on the Basal Long Soak charts). After soaking, the plants are either immediately stuck into the propagation media or placed into cold winter storage. Biologically, this extended soak relies entirely on hydraulic suction; as the upper stem naturally loses moisture, it creates a vacuum that actively pulls the aqueous IBA solution deep into the xylem.

**Re-hydrating Dormant Plant Treatments:**

Rose bushes and other plants typically ship in a dormant, dehydrated state. Submerging the entire root system in the IBA solution for several hours prior to planting serves a vital dual purpose: it fully rehydrates the plant tissues while simultaneously delivering the rooting hormone. Immersing the bare roots in this manner dramatically reduces transplant shock, accelerates the timeline for new root emergence, and encourages the plant to develop a denser, healthier feeder root architecture once in the ground.

**TREATMENT OF UN-ROOTED CUTTINGS (URC) FOR TRANSIT & STORAGE**

For high-volume unrooted cuttings (URCs) like Chrysanthemums, breeding stations apply a foliar spray of Hortus IBA Water Soluble Salts, mixed with a colored identification dye, directly to the loose cuttings. Once dry, the cuttings are cold stored or packed for shipping. During transit to the rooting station, the leaves absorb the IBA and naturally translocate it to the basal end, beginning the physiological process of root initiation before the cuttings even arrive. This "in-transit" initiation significantly reduces required bench time at the destination rooting station, accelerating overall production cycles. In professional plant programs, this pre-treatment option is offered by Syngenta-Yoder Chrysanthemums.

## CALLUS FORMATION AND METABOLIC BALANCE

### Wound Healing vs. Root Formation

In commercial propagation, a callus is a mass of undifferentiated parenchyma cells that forms to seal the basal wound of a severed cutting. While a light, healthy callus is a necessary first step for pathogen defense, its biological relationship to true roots depends on the species:

**Direct Root Formation:** Roots form internally from vascular tissue and push their way outward through the callused wound.

**Indirect Root Formation:** Roots differentiate directly from the callus cells themselves.

### Balancing Metabolic Energy (Foliar vs. Basal Methods)

Successful root formation requires strict metabolic balance. The delivery speed and concentration of the rooting hormone directly dictate whether the cutting reserves its energy to push true roots, or exhausts its energy building a defensive callus.

**Foliar Methods (The Balanced Release):** Foliar applications, specifically the Spray Drip Down and Total Immerse methods, utilize the plant's natural vascular highway to deliver a continuous, slow-release trickle of auxin down to the basal wound. This sustained, regulated pressure perfectly balances the plant's internal metabolic reservoir. By mimicking natural biology, it provides the cutting with just enough energy to form a healthy, light callus to seal the wound, while safely reserving the bulk of its metabolic energy to push true roots.

**Basal Methods (The Overload Risk):** Conversely, applying a Basal Quick Dip at an excessively high concentration creates an instant chemical overload that can force the plant into a severe wound response. Reacting to this intense chemical pressure, the cutting expends its entire metabolic reservoir simply to build a massive, restrictive callus. With its stored energy completely depleted by this defensive wound response, the cutting lacks the fuel required for actual root differentiation, causing it to permanently stall. In these instances, a massive, swollen callus is not a sign of impending roots; it is a critical diagnostic warning of chemical exhaustion.

**'Callus' Can Be a Visual Warning: A massive, swollen callus is not a sign of impending roots.**

Callus is a critical diagnostic warning of chemical exhaustion and a permanent physiological stall. Selecting the correct application method and adhering to proven trial rates is critical to moving the crop safely past the initial callus phase and into active root growth.

(Discussed in the PLANT CARE AND CONTROL, Section 10).

## TRIAL RATES: Listed on the Hortus IBA Water Soluble Salts Label

1. **Establish the Trial Rate** from the charts below for the method and plant type, in parts per million (ppm) IBA
2. **Calculate the weight of Salts** for any ppm IBA and any liquid volume.
   Use the chart on HORTUS IBA WATER SOLUBLE SALTS, Section 4, or
   **Online Calculator (http://rootinghormones.com/calculatesalts.htm).**
3. **Mix the Solution** using instructions on Section 4

### FOLIAR SPRAY DRIP DOWN & TOTAL IMMERSE METHODS

Apply the solution to the Leaves (Foliar):

**Spray Drip Down:** Stick in Media. Then, spray IBA Solution on Leaves.

**Total Immerse:** Immerse the cuttings in the IBA Solution, Then, Stick in Media.

;

| **Cutting Type** | **Trial Rate ppm IBA** |
|---|---|
| Annuals, Perennials, and Chrysanthemums | 80 - 250 ppm IBA |
| Herbaceous and Hard-to-Root Perennials | 250 - 1500 ppm IBA |
| Woody Ornamental Cuttings | 300 - 1500 ppm IBA |

### BASAL QUICK DIP METHOD

Apply the solution to the basal end of cuttings:

Dip the Basal End of the Cutting into the Solution for a Few Seconds. Then, Stick in Media.

| **Cutting Type** | **Trial Rate ppm IBA** |
|---|---|
| Annuals, Soft Perennials, Tender Ornamentals, and Tropical House Plants | 80 - 200 ppm IBA |
| Herbaceous Cuttings, Perennials, and Pot Roses | 150 - 1500 ppm IBA |
| Difficult-to-Root Herbaceous, Perennials, and Tropical House Plants | 500 - 1500 ppm IBA |
| Softwood Cuttings | 500 - 1500 ppm IBA |
| Hardwood Cuttings | 500 - 2000 ppm IBA |
| Difficult-to-Root Hardwood Cuttings | 2000 - 5000 ppm IBA |

Note: Alternate to high trial rates may be achieved using basal Long Soak.

### BASAL LONG SOAK METHOD

Apply the solution to the basal end of cuttings:

Immerse the Basal End of the Cuttings in Solution, for Approximately 12 to 24 Hours.
Stick in Media or Winter Store.

| **Cutting Type** | **Trial Rate ppm IBA** |
|---|---|
| Hard-to-Root Annuals and Perennials | 25 - 100 ppm IBA |
| Herbaceous Cuttings | 50 - 200 ppm IBA |
| Woody Ornamental Cuttings, Grapes, and Roses | 50 - 400 ppm IBA |

**METHODS SUMMARY**

| Method | Plant Type | Typical Use | Notes (basic) |
|---|---|---|---|
| **Spray Drip Down** | Leafy Herbaceous, Softwood, Semi-Hardwood, Annuals, Perennials | Lowest labor cost, no cross contamination risk. | Treat after sticking. Keep unused solution |
| **Total Immerse** | Large-leaf cuttings: Hydrangea, Trailing plants, Tissue Culture | Full solution coverage, bulk processing | Dip before sticking, Dispose solution after use |
| **Basal Quick Dip** | Hardwood, Dormant, or difficult woody species | Precision dosing at wound site, penetrates thick cuticles | Higher labor, dispose solution after use |
| **Basal Long Soak (with or without winter storage)** | Recalcitrant species, Rootstocks | Deep saturation, overcomes severe inhibitors | Higher labor; dispose solution after use 12-24 hour soak |

**COMPARISON: FOLIAR TOTAL IMMERSE vs SPRAY DRIP DOWN**

Using Hortus IBA Water Soluble Salt solutions, IBA enters the cutting through the cuticle and open stomata of the leaves. The hormone translocates by polar transport to the basal end of the cuttings, where root formation is triggered. It is used on actively growing leafy herbaceous and woody plant cuttings

| | Total Immerse | Spray Drip Down |
|---|---|---|
| **Timing** | Immerse cuttings into the solution, before sticking in media | Stick cuttings into media, spray solution onto leaves |
| **IBA Solution coverage** | All leaves receive uniform solution coverage | Coverage of the spraying depends upon efficiency of the sprayer |
| **Labor efficiency** | All cuttings are treated at one time | Requires either manual or automated spraying |
| **Cross contamination potential** | If different kinds of plant cutting are being treated, dispose of the solution between production lots | No contamination. Solution is used one time |
| **PPE, Zero hour REI. No restriction on re-entry** | Basic PPE | Sprayer requires mask, etc. Other times, basic PPE |

**COMPARISON: FOLIAR vs BASAL**

**Foliar:** Spray Drip Down and Total Immerse, best for leafy cuttings, delivering sustained IBA to ensure high quality and uniformity over a prolonged rooting period.

**Basal:** Quick Dip, ideal for dormant, non-leafy material, providing the rapid, intense penetration necessary to overcome natural inhibitors and force rooting. Long Soak is ideal for hard-to-root species.

| | FOLIAR: **Total Immerse**<br>**Spray Drip Down** | BASAL: **Quick Dip**<br>**Basal Long Soak** |
|---|---|---|
| **Efficacy** | IBA is absorbed through leaves. Translocation by polar transport to basal end for root formation | IBA is delivered directly to the basal end for root formation |
| **Cuttings Used** | Actively growing leafy cuttings of herbaceous and woody plants | Actively growing leafy cuttings. Dormant or leafless cuttings, of herbaceous or woody plants |
| **Phytotoxicity** | None, using Hortus IBA Water Soluble Salts aqueous solutions | None, using Hortus IBA Water Soluble Salts aqueous solutions. |
| **Cross Contamination** | Total Immerse: dispose after production lot.<br>Spray: no cross contamination | Immerse Solutions: dispose after production lot. |
| **Protection (PPE)** | Sprayer person requires mask, etc.<br>Other: basic PPE | General handling use normal PPE |

**While a single primary rooting treatment is sufficient for many crops, difficult-to-root species often exhaust their internal energy before roots can fully form. Section 6 details how to utilize multiple spray applications to safely sustain the rooting signal over time.**

## SECTION 6 MULTIPLE SPRAY DRIP DOWN APPLICATIONS

### MULTIPLE APPLICATIONS (Booster)

While the primary use of rooting hormones is plant propagation from cuttings, a single initial application may be insufficient to carry a crop through to a fully developed root system. The initial rooting treatment can be performed using any method (Spray Drip Down, Total Immerse, or Basal Quick Dip) to successfully trigger root induction and establish the cutting's initial "Metabolic Reservoir" (as defined by Dr. Cohen's biochemical research). However, because the plant relies on a continuous supply of IBA, this internal reservoir may deplete over time, causing root development to stall.

To safely intervene, growers must utilize one or more booster applications. These secondary treatments must be applied exclusively via the foliar Spray Drip Down method. Because the cuttings are already stuck in the media, uprooting them for additional basal dips would physically destroy the delicate, newly forming root cells. Instead, the overhead foliar spray leverages the plant's natural Polar Auxin Transport system (mapped by Dr. Davies) to actively translocate the hormone downward. This effectively refills the internal auxin reservoir at the basal wound without causing physical disturbance.

Multiple Spray Drip Down applications are used for much more than just the initial propagation of cuttings. No matter which primary rooting method is utilized, multiple foliar sprays can be applied to safely prevent physiological stalling. This sustained chemical pressure provides broad utility across the entire facility, serving as a critical tool for stock plant improvement, crop leveling, and transplant root regeneration.

**MATERIALS AND METHODS: Multiple Applications**
Execution relies on a strict multiple application protocol using aqueous Hortus IBA Water Soluble Salts solutions. Because the success of foliar applications relies on the hormone entering through the cuticle and open stomata, all foliar applications must be performed while the plant's stomata remain open and the leaves are turgid to readily absorb the IBA solution. Depending upon ambient conditions, spraying may occur in the early morning or when the growing area is cool. This avoids sun-related stress and ensures the cuttings are fully turgid during application.

**The First Application (Any Method)**
Apply the IBA solution to the unrooted cuttings prior to, or immediately after, sticking. For this initial application, growers can use foliar Spray Drip Down, Total Immerse, Basal Quick Dip, or Basal Long Soak. While standard practice dictates applying the primary Spray Drip Down applications on the day of sticking, this initial application window is highly flexible. The initial rooting product application may be safely performed the day after sticking, or unrooted cuttings can be treated with rooting hormone and then stored for later sticking. Once complete, the cuttings must remain firmly stuck and undisturbed in the propagation media. (For crop timing suggestions, refer to the PROVEN PROTOCOLS section below).

**Operational Adjustments (Micro-Mist and Equipment)**
The first and secondary trial rates listed for the Spray Drip Down method must be adjusted based on the facility's specific operational equipment. For example, when high-efficiency micro mist sprayers are utilized, the applied ppm IBA solution trial rates can often be reduced below the standard table rates. However, because less rooting hormone is delivered per application, the interval between these secondary booster applications must be shortened accordingly to maintain the necessary chemical pressure.

Never use micro mist where the spray goes into uncontrolled areas. It is only to be used in tunnels where the drift is retained.

**Secondary Boosters and Timing (using Spray Drip Down ONLY)**
All secondary applications are strictly restricted to the foliar Spray Drip Down method. Removing cuttings for subsequent basal treatments would physically destroy the delicate new root cells. Instead, the overhead foliar spray safely leverages the cutting's vascular system to translocate IBA directly down to the basal end. Because internal auxin depletion rates vary heavily by plant type and operational goals, the specific timing of these booster applications must be tailored to match the plant's exact metabolism:

- **Intensive Early Boosters (1 to 3 Days):** For highly specific crop management (such as accelerating fast-rooting herbaceous crops or executing an intensive initial loading phase for woody softwoods), early secondary applications can be performed just 1 to 3 days after the initial sticking.
- **Fast-Metabolizing Plants (7 to 10 Days):** Generally, active herbaceous crops, annuals, and perennials deplete their internal auxin quickly. Standard secondary Spray Drip Down applications are typically required about 7 to 10 days after the initial sticking to prevent stalling.
- **Mature Woody Tissues (10 to 14 Days):** Conversely, because mature woody tissues metabolize and root much slower, their secondary booster applications must be spaced further apart, typically at 10 to 14 day intervals to safely sustain the chemical pressure without inducing toxicity.

**ADVANCED CROP MANAGEMENT (Plant Improvement)**
**Crop Leveling:**
In situations where a crop is rooting unevenly, additional multiple Spray Drip Down applications can be strategically utilized to "level" the crop. Applying these subsequent sprays at about ten-day to two-week intervals helps lagging cuttings catch up to the more vigorous ones, ensuring the entire bench is ready for transplant at the exact same time.
(Discussed in MULTIPLE SPRAY DRIP DOWN APPLICATIONS, Section 6**)**

**Eliminating Stalling:**
To actively eliminate physiological stalling, growers should utilize multiple Spray Drip Down applications (Discussed in TROUBLESHOOTING Common Propagation Issues, Section 10).

**PROVEN PROTOCOLS: Real World Professional & Academic Research**
The efficacy of multiple foliar applications is documented in academic research and large-scale commercial production trials. The following protocols are taken from public sources, as specified.

**The Biological Imperative (Dr. Davies):**
Dr. Davies' foundational research demonstrates that mature plant tissues are structurally recalcitrant, requiring higher exogenous auxin levels and a longer duration of chemical pressure to root. Attempting to force roots with a single, massive toxic dose of IBA actively decreases primordia elongation, reducing root length and quality. This biological imperative dictates the need for scaled trial rates (up to 1500+ ppm IBA for mature woody tissues) and extended booster intervals (up to 14 days), as multiple sprays safely sustain chemical pressure without inducing toxicity.

(Davies, F. T., Jr., and J. N. Joiner. 1980. "Growth Regulator Effects on Adventitious Root Formation in Leaf Bud Cuttings of Juvenile and Mature Ficus pumila." Journal of the American Society for Horticultural Science, 105(1): 91-95.)

**The Decker Nursery Protocol (High-Volume Production):**
To manage large-scale woody ornamental propagation, Decker Nursery transitioned exclusively to over-spray methods, completely eliminating labor intensive basal dips. To achieve this, they utilize an intensive initial loading phase. In their published trials, summer softwoods were sprayed for three consecutive days immediately after sticking at 500 to 1500 ppm IBA. For winter hardwoods, they applied 1500 to 2500 ppm IBA over three days, followed by standard 2-week interval boosters. While this consecutive day spraying is an aggressive adaptation uniquely calibrated to their facility, it perfectly validates the core biological principle: continuously sustaining chemical pressure safely builds the necessary metabolic reservoir to root difficult crops. By adopting this multiple application approach, Decker achieved a 20% increase in daily production while drastically improving worker safety.

(Decker, B. M., and D. Graff. 2016. "Foliar applications of rooting hormone at Decker Nursery." Combined Proceedings of the International Plant Propagators' Society, Volume 66.)

**Osteospermum Trials at Dummen Orange (Dr. P. Allen Hammer):**
Evaluating K-IBA rates, Dr. Hammer found 600 ppm IBA to be the absolute optimal concentration for Osteospermum. Cuttings receiving a 600 ppm IBA treatment on the day of sticking, followed by a second 600 ppm IBA booster 10 days later, developed significantly heavier and more robust root systems than those receiving a single application. This 600 ppm IBA rate sits optimally in the standard 250-1500 ppm IBA range, and the 10-day booster perfectly aligns with the established metabolic depletion window for herbaceous crops.

(Hammer, P. Allen. "Plant Propagation from Cuttings Using Single and Multiple Foliar Applied Spray Drip Down.")

**The Ball FloraPlant "Ice Cream" Trials (Bench Times):**
Evaluating 100 ppm IBA foliar sprays on fast-growing herbaceous crops, Osteospermum and Geranium showed 90-100% callus initiation within five days (compared to 40-50% for untreated cuttings). This perfectly hits the lower end of the standard range for fast-metabolizing annuals. Because they root so rapidly, a single initial application successfully accelerated greenhouse turnover, allowing liners to be moved out of propagation 4 to 7 days sooner.

(Carlsson, Kris, and Luís Muñoz. 2016. "Use Rooting Hormone or Eat Ice Cream?..." GrowerTalks, September 2016, pp. 58-60.)

**Bailey Nurseries (Labor and Cost Reduction):**
Bailey documented massive operational advantages by shifting from manual basal dips to foliar sprays. Spraying stuck crops freed up planting crews and eliminated the risk of pathogen transfer associated with communal dip solutions. Financially, this generated direct labor and operational savings.

(Drahn, Samuel R. 2007. "Auxin Application via Foliar Sprays." Combined Proceedings of the International Plant Propagators' Society, Volume 57.)

**While stem cuttings are the most common avenue for mass production, plant propagation encompasses a much wider biological spectrum. Section 7 details how to apply these precise rooting treatments across alternative vegetative methods, including tissue culture, grafting, and division.**

# SECTION 7 PROPAGATION SEXUAL AND ASEXUAL METHODS

## SEXUAL AND ASEXUAL PROPAGATION

Successful propagation requires matching the IBA application method to the plant's fundamental physiological state. Understanding the biological divide between sexual and asexual reproduction is critical for optimizing facility labor, minimizing handling stress, and delivering the exact metabolic signal required for uniform crop development.

## SEXUAL (SEED) PROPAGATION

Sexual propagation involves the union of pollen and egg (meiosis) to combine genetic material from two distinct parents. Because this genetic mixing produces unique offspring with unpredictable traits, most commercial cultivars do not breed "true" from seed, creating unwanted variability in the crop. While not ideal for replicating specific commercial cultivars, seed propagation is essential for breeding new plant varieties, developing vigorous hybrid rootstocks, and maintaining genetic diversity. Never treat unsprouted seeds with exogenous IBA solutions, as the chemical pressure can severely inhibit or completely halt natural germination rates.

**Post-Germination Care:**

Once seeds have successfully germinated and the plantlets develop 4 to 8 true leaves, a low-rate Spray Drip Down application can be safely utilized to stimulate a thicker, more robust root mass without physically disturbing the fragile seedlings.

## ASEXUAL (VEGETATIVE) PROPAGATION

To ensure strict crop uniformity, commercial growers rely almost exclusively on asexual vegetative propagation. This process utilizes cellular replication (mitosis) from the living tissue of a single parent (stems, roots, or leaves) to create an exact DNA copy without any genetic mixing.

**Cellular Dedifferentiation:**

Asexual propagation relies on the ability of mature, specialized plant cells to return to an undifferentiated state (forming a callus) and then generate entirely new adventitious organs, such as roots, when triggered by the correct auxin signal.

**True-to-Type Clones:**

Because there is no genetic mixing, the resulting offspring are identical to the parent plant in every characteristic. Asexual reproduction also bypasses the plant's juvenile phase, allowing for significantly faster maturation and flowering.

**Mass Production:**

Vegetative propagation encompasses a variety of techniques, including division, bulbs, tubors, grafting, layering, and tissue culture. However, propagation from cuttings remains the most efficient way to mass propagate new plants. Across all these methods, Hortus IBA Water Soluble Salts solutions provide the highly targeted metabolic signal required to ensure high-quality, uniform clones.

## CATEGORIES OF ASEXUAL VEGETATIVE PROPAGATION

**Rooting Cuttings:** The excision of stems, leaves, or roots from a stock plant to generate independent, genetically identical clones. Propagation discussed throughout this article.

**Layering:** The induction of adventitious roots on a stem while it remains physically attached to the mother plant.

**Grafting:** The mechanical fusion of a desirable scion shoot onto an established rootstock, combining superior canopy traits with vigorous, disease-resistant roots. The bare roots of the rootstock can be chemically treated prior to planting to accelerate establishment.

**Stenting:** A specialized technique (combining the Dutch words stek for cutting and enting for grafting) that simultaneously grafts a scion onto an unrooted rootstock while initiating roots on the combined unit.

**Division:** The physical separation of a mature, clumping crown into multiple, individually rooted plantlets.

**Tissue Culture (Micro-Propagation):** The laboratory-based cultivation of minute tissue samples to rapidly produce massive quantities of disease-free clones.

## METHODS FOR ASEXUAL PROPAGATION

### CUTTINGS

Cuttings are severed vegetative parts (stems, leaves, or roots) taken from a stock plant to regenerate a new, identical clone. They are the most efficient and widely utilized plant material for commercial mass production. Because cuttings are the absolute foundation of modern horticulture, the comprehensive physiological mechanisms, trial rates, and specific Hortus IBA Water Soluble Salts application methods are detailed extensively throughout the remainder of this article.

### LAYERING

Layering involves inducing roots on a stem while it is still attached to the parent plant. While generally inefficient for mass production compared to cuttings, this method is useful for propagating difficult-to-root species or preserving a specific branch of a mother plant.

**Protocol:** Once the rooted portion is severed from the stock plant, the exposed bare roots should be treated to ensure rapid establishment. Use the Spray Drip Down or Total Immerse methods with aqueous Hortus IBA Water Soluble Salts. Trial rates typically match the Basal Quick Dip trial rates for the specific species (e.g., 500-2000 ppm IBA for woody plants).

### GRAFTING AND BUDDING

Grafting is an asexual reproduction method that involves mechanically attaching a scion shoot to a rootstock. This technique allows growers to combine the desirable shoot traits of a specific strain, such as unique flowering characteristics, with a rootstock that offers superior vigor or disease resistance. While less common than stem cuttings for many crops, grafting is a valuable tool for specific high-performance combinations.

**Protocol:** To ensure rapid establishment and improve survival rates, the roots of the rootstock should be treated prior to planting, using Spray Drip Down or Total Immerse. Trial rates typically range from 500-2000 ppm IBA, depending on the woodiness of the rootstock.

### STENTING (Simultaneous Grafting and Rooting)

Stenting merges grafting and rooting into one highly efficient step by attaching a desired scion directly onto an unrooted rootstock. Ideal for crops like greenhouse Roses and Prunus, this method requires a straight, disbudded rootstock perfectly matched in diameter to a short scion (with 1-2 dormant buds) to guarantee exact cambial alignment. The two pieces are joined, often via a splice, whip-and-tongue, or Omega cut, and firmly secured.

**Protocol:** Treat the newly joined unit as a single unrooted cutting. Apply Hortus IBA Water Soluble Salts to the basal end using a Basal Quick Dip or Basal Long Soak. This simultaneously triggers root formation and accelerates graft healing.

**Aftercare:** Stick the treated unit into the propagation media under high humidity to prevent moisture loss while the union heals and roots develop.

### DIVISION

Division is used on clumping perennials to separate a mature crown into smaller rooted segments.

**Protocol:** After dividing and transplanting, the Spray Drip Down method is used on the new plantlets at a trial rate suitable for the variety. To ensure survival and rapid establishment, multiple spray applications may be made at 5-10 day intervals until successful root formation is evident.

**SPECIAL NEED: Tissue Culture (Micro-Propagation)**
Tissue culture (TC) rapidly produces large quantities of disease-free clones from minute tissue samples in a sterile environment. However, it differs significantly from standard cuttings regarding genetic stability. While standard cuttings preserve the parent plant's physical structure for high genetic stability, tissue culture forces regeneration, often from single cells. This forced growth increases the risk of off-type somaclonal variation, chimera breakdown, and mutations caused by high laboratory hormone levels.

**Stage IV Acclimatization Challenges:** When TC plantlets are transplanted to the greenhouse during Stage IV acclimatization, they are anatomically unique and highly fragile.

**Root Limitations:** TC root systems lack functional root hairs, which severely limits water uptake.

**Foliar Vulnerability:** Having grown in 100% humidity, TC stomata are slow, non-functional, and do not close properly to prevent water loss.

**TC Adapted Total Immerse Protocol:**
To survive the harsh transition from sterile media to soil, the root system must be stimulated immediately. Because the plantlets are exceptionally tender, this method utilizes a basket to minimize physical handling.

**Clean:** Gently wash off all agar residue. This is critical because the sugars in the agar will attract pathogens once introduced to non-sterile soil.

**Treat:** Place the plantlets in a basket and totally immerse them for a few seconds (e.g., 5 seconds) in a solution of aqueous Hortus IBA Water Soluble Salts. Typical trial rates for this delicate tissue are 10–50 ppm IBA.

**Aftercare:** Plant immediately and cover TCs with transparent domes, or place in a mist environment, to maintain high humidity while functional stomata develop.

**Regardless of the specific propagation method chosen, the physical environment of the greenhouse dictates the speed of the plant's metabolic engine. Section 8 outlines the critical temperature, humidity, and sanitation controls, along with Organic Production, required to support the rooting process.**

## SECTION 8 FACILITY MANAGEMENT & SPECIAL NEEDS

### TEMPERATURE CONTROL

**Root Zone Temperature:** The soil temperature must be high enough to drive the enzymatic conversion of IBA into IAA.

Too Cold (< 65°F): At lower temperatures, the enzymes slow down; the plant has the IBA hormone but cannot process it. This leads to stalling, where heavy callus forms but the roots do not elongate.

Too Hot (> 80°F): If temperatures spike too high, plant respiration rates also spike. The cutting will burn through its vital carbohydrate reserves before roots can form, inevitably leading to rot or tissue necrosis.

**Air Zone Temperature:** The ambient air should be kept cooler than the soil to suppress top growth. This forces the plant to spend its energy on root generation rather than shoot expansion. Additionally, this cooler temperature lowers the Vapor Pressure Deficit (VPD), which significantly reduces stress on the leaves.

### HUMIDITY CONTROL

**Softwood and Greenwood:** These active cuttings require intermittent mist or high-humidity fog to maintain turgidity. The operational goal is to maintain a thin film of water on the leaf surface without completely saturating the rooting media.

**Hardwood:** Because they are dormant and leafless, these cuttings can often be successfully propagated in simple cold frames or under polyethylene tents.

**SANITATION**

The choice of application method directly dictates the facility's disease risk and the ability to manage the spread of pathogens. Growers must never dip cuttings directly into the primary stock container, as this will spread pathogens from a single infected stem to the entire batch. Always decant the required amount into a separate reservoir and discard the used solution afterward.

- **Foliar Methods:**
  - **Spray Drip Down:** Solutions are used one time, ensuring absolutely zero cross-contamination.
  - **Total Immerse:** When used on homogeneous crops (the same batch), this solution can be safely reused. When processing different crops, this solution should be discarded between production lots.
- **Basal Methods:**
  - **Basal Quick Dip:** Similar to immersion, this solution can be reused on homogeneous crops but must be discarded between lots when switching to different crops.
  - **Basal Long Soak:** These solutions are strictly used one time.

**ORGANIC PRODUCTION**

Hortus IBA Water Soluble Salts contain synthetic IBA and lack NOP (National Organic Program) organic certification. However, they can still be used in the establishment of organic perennial crops under specific transitional conditions.

- The NOP Standard: According to the official USDA NOP regulations regarding seeds and planting stock (7 CFR § 205.204): "Nonorganically produced planting stock to be used to produce a perennial crop may be sold, labeled, or represented as organically produced only after the planting stock has been maintained under a system of organic management for a period of no less than 1 year".
- **First Year (Transition):** This standard permits growers to use non-organic planting stock (such as cuttings treated with synthetic IBA) to establish perennial crops (e.g., grapes, fruit trees, berries), provided the plants are subsequently managed organically for at least 12 months.
- **After First Year (Certification):** Any harvests during this initial 12-month transition period must be sold as **conventional**. Thereafter, the crop is eligible to be officially certified and sold as **organic**.

**While the biological requirements of a cutting remain constant, the way a facility manages those environmental and chemical controls must adapt to its size. Section 9 explores how to optimize these propagation methods for both large-scale commercial operations and smaller nurseries.**

## SECTION 9 PRODUCTION SCALE

**IMPROVING PROPAGATION FOR ANY FACILITY SIZE**

To propagate and grow, no matter the size of the growing facility, the ultimate goal is to produce a high quality, uniform crop. While the physiological requirements of the cutting remain constant, the method of rooting hormone application must adapt to the facility's scale, labor constraints, and capital resources. Regardless of operation size, Hortus IBA Water Soluble Salts solutions offer versatility through their application in many methods.

**LARGE-SCALE PRODUCTION**

The primary operational needs are labor efficiency and crop uniformity. High-production methods are essential to reduce per-unit costs, often justifying the investment in automated equipment.

- **Foliar Spray Drip Down:** Ideal for leafy cuttings during the active growing season. This method allows sticking crews to focus solely on rapid planting without the hindrance of chemical Personal Protective Equipment (PPE). Once the cuttings are stuck, lots are treated simultaneously using hydraulic or boom sprayers, drastically reducing labor costs.
- **Foliar Total Immerse:** Best for large, homogeneous batches. Cuttings are treated in bulk prior to sticking, ensuring complete, uniform solution coverage with minimal physical handling.
- **Basal Quick Dip:** While it incurs higher labor costs due to the individual handling of cuttings (or small bundles) prior to sticking, it remains one of the most widely used methods in commercial plant

propagation. Its necessity is dictated by the specific biological needs of the plant variety. It is absolutely essential for rooting leafless cuttings, dormant hardwood, or heavily lignified mature tissues where foliar sprays cannot penetrate. Furthermore, it allows for highly precise, targeted chemical dosing directly at the wound site, making it a critical tool for processing diverse or highly variable crop lots.

**SMALL-SCALE PRODUCTION**

The primary operational needs are flexibility and low operating costs. While labor constraints may be looser than in massive facilities, the demand for professional, consistent results remains exactly the same.

**Foliar Spray Drip Down**: Easily adapted using simple backpack or hand-pump sprayers. This offers smaller growers the exact same physiological benefits and sanitation standards as large-scale nurseries but without the heavy capital investment in automation.

**Foliar Total Immerse:** Requires only basic, inexpensive equipment, such as plastic tubs and simple wire strainers, to treat bulk cuttings effectively and uniformly.

**Basal Quick Dip:** While manual and labor-intensive, it remains an excellent, highly targeted, and low-cost option for processing highly diverse, small-batch production lots where different plant varieties require completely different ppm IBA trial rates. Utilizing only basic plastic or glass dipping containers, this method allows propagators to seamlessly switch between delicate, low-dose treatments and aggressive, high-dose treatments side-by-side on a mixed-taxa bench without compromising adjacent crops.

**Once the rooting process is successfully initiated across the facility, the grower must guide the crop to the finish line. Section 10 focuses on safely hardening off the crop, regenerating damaged roots during transplanting, and troubleshooting common stalls.**

## SECTION 10 PLANT CARE AND CONTROL

Successful plant care requires actively managing the transition from a rooted cutting to a self-sufficient plant. By pairing environmental management with targeted applications of Hortus IBA Water Soluble Salts, growers can mitigate transplant shock, break physiological stalling, and correct irregular rooting to guarantee a uniform finished crop.

### OVERCOMING TRANSPLANT STALL

When a plant is "stepped up" into a larger container, the delicate fine root hairs responsible for water and nutrient uptake are often damaged. This causes top vegetative growth to temporarily stall as the plant redirects its stored energy to root repair. Applying a foliar Spray Drip Down treatment during this transition translocates IBA directly down to the damaged root zone. This rapidly stimulates new secondary roots and restores hydraulic uptake, helping the plant quickly acclimatize to its new environment without requiring manual handling of the fragile root ball.

(Note: For complete root regeneration protocols, specific application methods, and trial rates, refer to PROPAGATION METHODS, Section 5).

### TROUBLESHOOTING COMMON PROPAGATION ISSUES

**Resolving Physiological Stall (Heavy Callus):** Occasionally, a cutting will form a heavy basal callus and survive for weeks without pushing actual roots, eventually starving. This physiological stall occurs when the plant completely exhausts its internal "Metabolic Reservoir" (as defined by Dr. Cohen's research). The plant uses up its initial stored IBA simply to build the protective callus, leaving no converted auxin left to differentiate actual root tissue.

(Note: The biological relationship between wound healing and root emergence is discussed in ROLE OF CALLUS IN ROOT FORMATION, Section 5).

To safely eliminate this physiological stalling, growers must utilize multiple Spray Drip Down applications. Pulling a callused cutting from the media to re-dip it basally would physically destroy the delicate forming tissues. Instead, by applying secondary foliar treatments over a few weeks at typical rooting rates, the plant's natural Polar Auxin Transport system safely translocates the new IBA downward. This effectively refills the depleted metabolic reservoir at the basal sink, providing the sustained chemical pressure required to push the stalled cutting to root.

**Eliminating Uneven Rooting (Inconsistent Rate):** When some cuttings in a tray root vigorously while adjacent ones fail, the inconsistency can stem from several operational factors, such as random selection from variable stock blocks, improper or non-uniform handling and storage, or mixing plant lots from different sources. However, if the starting material is uniform, the primary culprit for irregular rooting is an inconsistent IBA application. Uneven physical dosages commonly occur due to varied handling times during a manual Basal Quick Dip, or from incomplete foliage coverage during an initial Spray Drip Down application. Due to this uneven application, each cutting builds a drastically different "Metabolic Reservoir" (Dr. Cohen). Cuttings with under-filled reservoirs simply run out of stored auxin before roots can fully form, causing them to stall while their neighbors thrive.

**Fixing and Preventing the Uneven Crop (leveling):** If the cuttings are already stuck and rooting unevenly, growers can utilize additional multiple Spray Drip Down applications to "level" the crop. Applying these subsequent booster sprays safely refuels the lagging cuttings, helping them catch up to the more vigorous ones and ensuring the entire bench is ready for transplant at the exact same time. To eliminate variance from the start, growers can switch to the Total Immerse method for their initial application. The entire batch of cuttings is submerged together prior to sticking, guaranteeing 100% solution coverage. Assuming the cuttings come from a homogeneous lot, every cutting equally utilizes its Polar Auxin Transport system to build a fully stocked metabolic reservoir, resulting in uniform rooting across the entire crop.

## ACCLIMATIZATION: FROM STOCK PLANT TO FINISHED CROP

### MANAGING INITIAL SHOCK AND MIST TIMING

When severed, cuttings lose their water source and must rely entirely on artificial mist to survive the rooting cycle. However, the chosen IBA application method dictates exactly when the misting cycle should begin:

- **Spray Drip Down:** Cuttings must be turgid prior to application. Misters must be temporarily turned off and excess water allowed to evaporate to prevent diluting the rooting hormone. Allow the sprayed solution to dry completely on the leaves (approximately 45 minutes) before turning the misting cycle back on.
- **Total Immerse & Basal Quick Dip:** Because the IBA is applied before planting, the treated cuttings are immediately stuck into the media. The misters should be turned on right away to maintain vital hydration.

### WEANING AND ENVIRONMENTAL HARDENING

Once the adventitious root system has formed, the cutting is no longer highly sensitive. At this stage, growers must shift the operational priority back to acclimatization and gradually wean the plant from its dependence on artificial mist. Execute the following steps to properly harden off the crop:

- **Step Down the Mist:** Systematically decrease the frequency of mist cycles. This intentionally creates a mild vapor pressure deficit that forces the stomata to regulate water loss and actively compels the new roots to pull moisture from the media.
- **Monitor and Adjust:** Observe if the plants wilt significantly between mist cycles, The root system is not yet sufficient. In this case, slightly increase the humidity and re-evaluate the crop in a few days.
- **Achieve Ambient Independence:** Continue this weaning process until the ultimate goal is reached: a state where the foliage remains completely dry, and the plant maintains turgor solely through active root uptake in ambient greenhouse conditions.
- **Introduce Fertilization:** Concurrently, initiate a species specific fertilization program. Because newly rooted plants can no longer survive strictly on stored carbohydrates, external nutrients must be introduced to successfully fuel this rapid new vegetative growth.

**PREVENTING DESICCATION DURING FOLIAR DRYING**

If shoot tips droop or leaves curl immediately after sticking, a common issue with softwoods, transpiration has likely exceeded water uptake. Because foliar spray solutions require approximately 45 minutes to dry and absorb, the ambient air cannot be too dry, or the plant will lose moisture faster than it can replace it. To protect the crop during this critical drying window, follow these operational steps:

- **Monitor the Crop:** Watch softwoods closely immediately after sticking; drooping or curling indicates dangerous moisture loss.
- **Time the Application:** Always apply foliar methods in conditions when the ambient environment is favorable to hydrated cuticles and open stomata.
- **Manage the VPD:** Timing the application for these optimal periods effectively reduces the vapor pressure deficit (VPD). This allows the solution to safely dry and absorb without desiccating the cutting.

**Knowing how to fix a stalled crop is crucial, but understanding the underlying "why" elevates a grower's entire operation. Section 11 takes a deep dive into the foundational biochemical engines and physiological maps discovered by Drs. Cohen and Davies that make these techniques possible.**

## SECTION 11 TECHNOLOGY: STUDIES BY DRS. COHEN & DAVIES

**THE SYNTHESIS OF SCIENCE AND PRACTICE**

The transformation of plant propagation from a traditional art into a reproducible science relies entirely on one core principle: aligning the chemistry of the applied hormone with the specific physiological state of the plant tissue. By understanding biological delivery systems and metabolic engines, growers can precisely optimize their application of Hortus IBA Water Soluble Salts and methods. This scientific approach drastically increases large-scale efficiency, bypasses recalcitrant growth, and significantly reduces physical labor.

The highly effective commercial techniques detailed in this article were developed by extensively studying the foundational, independent research of two distinguished plant physiologists. While neither scientist was directly involved in the development of these commercial methods or products, their academic rigor provided the precise biological roadmap necessary to modernize plant propagation globally. In grateful acknowledgment, this article synthesizes their published scientific discoveries with modern growing practice:

- Dr. Jerry Cohen: Biochemical insights (the "Metabolic Reservoir" and ß-oxidation).
- Dr. Frederick Davies: Physiological mapping (Polar Auxin Transport and the Cone of Juvenility).

**NATURAL AUXIN SYNTHESIS: How and Where Plants Produce IAA and IBA**

In nature, plants continuously manufacture their own internal rooting hormones, primarily Indole-3-acetic acid (IAA) and highly stable trace amounts of Indole-3-butyric acid (IBA). This natural synthesis occurs in the rapidly dividing tissues of the upper plant, most notably within the apical meristems (shoot tips) and young, actively expanding leaves. Biochemically, the plant produces IAA by converting the amino acid tryptophan through a series of complex enzymatic steps. Once manufactured at the top of the canopy, these native auxins are actively pumped downward through the vascular tissue to the root zone via Polar Auxin Transport. While IAA serves as the plant's primary, rapidly metabolized hormone for immediate growth, naturally occurring IBA functions as a crucial, slow-release storage form. When a cutting is severed and requires sustained energy to form new roots, the plant relies on a process called ß-oxidation to slowly convert its stored IBA back into active IAA, ensuring a steady, biologically regulated rooting signal.

Understanding this natural biological framework provides further verification that applying aqueous IBA solutions, particularly through foliar methods, perfectly mimics the plant's native rooting processes, leveraging its own built-in transport and conversion systems.

## THE BIOCHEMICAL ENGINE (DR. COHEN)

The pioneering research of Dr. Cohen fundamentally shifted the understanding of auxin physiology in plant propagation, moving the paradigm away from simple exogenous dosage models to complex, plant-regulated metabolic pathways.

### The Problem of Pure IAA

While both Indole-3-acetic acid (IAA) and Indole-3-butyric acid (IBA) are endogenous auxins found within plants, pure IAA is fundamentally flawed for commercial application. Other than for laboratory research, it is never used commercially because it is simply too volatile. This instability is due to enzymatic degradation (plants possess endogenous IAA-oxidases, derived internally, that actively destroy free IAA to prevent toxicity) and photo-oxidation (IAA degrades rapidly when exposed to light).

### The Solution: IBA Delivery and The “Metabolic Reservoir”

Dr. Cohen's work isolated the functional dichotomy between these hormones, establishing that unlike highly volatile IAA, IBA functions as a safe, stable precursor. This discovery established the concept of the metabolic reservoir, a biological buffering system wherein the plant safely sequesters the stable 4-carbon IBA molecule within its tissues. Acting much like a biological battery, this stored compound naturally resists immediate enzymatic destruction. Rather than flooding the plant with a toxic dose of active hormone, the plant systematically draws from this internal reservoir, converting the precursor into the active rooting hormone (IAA) at its own self-regulated pace.

**The Transformation Engine: Peroxisomal ß-Oxidation** (Technical Explanation: See Illustration)

To utilize the stored IBA, the plant must systematically chop two carbon atoms off the side chain. Dr. Cohen identified this as a strictly temperature-dependent, energy-driven thiolytic process occurring exclusively within the cellular peroxisomes, known as Peroxisomal ß-Oxidation. Mediated by specific genes, the plant executes a multiple mechanical process:

**Setup Phase (Activation):** An enzyme attaches a Coenzyme A (CoA) molecule to the IBA, creating IBA-CoA, which requires the plant to spend metabolic energy (ATP).

**Weakening the Carbon Chain:** The plant performs rapid chemical modifications to make the chain vulnerable.

**Final Cut:** A thiolase enzyme acts as "chemical scissors," cleanly cleaving off two carbon atoms to form a discarded Acetyl-CoA molecule. The remaining molecule is free, active Indole-3-acetic acid (IAA).

## THE HOMEOSTATIC LOOP: BIDIRECTIONAL TRANSPORT

Using radio-labeled and stable isotopes ([13C]-IBA), Dr. Cohen's group successfully mapped the homeostatic regulatory loops that govern the systemic distribution of these auxins. Prior propagation models assumed all applied auxins simply accumulated at the basal sink. Dr. Cohen, however, proved that plants actively regulate their internal hormone levels (homeostasis) using a bidirectional feedback loop:

**Primary Polar Transport (The Downward Sink):** Active IAA is strictly restricted to basipetal (downward) polar transport. This process ferries the hormone down to the basal wound to create the concentrated "physiological sink" necessary to trigger root initiation.

**Secondary Non-Polar Transport (The Upward Return):** Dr. Cohen demonstrated that the stable IBA precursor acts independently and can undergo non-polar translocation. Unlike IAA, the transport of IBA was not reduced by typical auxin transport inhibitors like N-1-naphthylphthalamic acid (NPA). If the basal sink becomes oversaturated, the plant utilizes this secondary route to actively shunt excess IBA acropetally (upward) through the xylem and non-polar phloem pathways.

This systemic bidirectional feedback loop definitively explains how plants autonomously mitigate basal tissue necrosis and chemical toxicity during commercial propagation. This completely explains the high safety threshold and maximum utilization achieved when applying multiple foliar applications of IBA through the Spray Drip Down method.

## THE PHYSIOLOGICAL MAP (DR. DAVIES)

**The Delivery System: Polar Auxin Transport (PAT)**
Using radioactive tracers in creeping fig (Ficus pumila), Dr. Davies mapped the plant's vascular transport system, proving exactly how a plant physically processes foliar-applied hormones. He elucidated a highly specific, three-step active transport pathway:

- **Dual-Pathway Entry:** When an aqueous IBA solution is applied to the foliage, it safely bypasses the outer leaf barriers by entering directly through the cuticle and open stomata.
- **Phloem Loading:** Once inside the leaf cavity, the exogenous auxin is absorbed into the plant's vascular bundles (specifically the phloem) alongside natural photosynthates.
- **Polar Auxin Transport:** Driven by a directional, one-way physiological flow, the plant actively ferries this hormone strictly downward from the shoot tip to the basal end of the cutting.

Dr. Davies demonstrated that the physical excision of a cutting severs this active vascular highway, transforming the basal wound into a physiological "sink". Because the continuously translocated IBA can no longer exit the stem, it pools at this biological roadblock, creating the intense, localized chemical pressure necessary to stimulate cambial activity, drive cellular dedifferentiation, and initiate the formation of root primordia.

**Tissue Sensitivity: The Cone of Juvenility vs. Mature Recalcitrance**
Beyond translocation dynamics, Dr. Davies defined how a plant's ontogenetic age and structural anatomy dictate its biochemical receptivity.

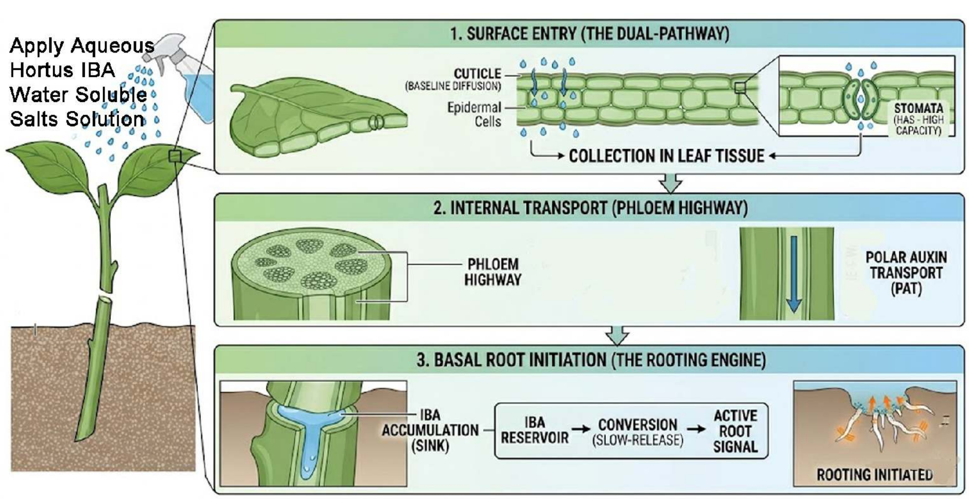
**The Cone of Juvenility:**

Dr. Davies mapped a highly sensitive physiological zone situated at the base of the stock plant near the root-shoot junction. Tissue originating within this zone exhibits high cellular plasticity, permeable cuticles, functional stomata, and consistently exhibits the highest RNA levels. Because these cells completely lack heavily lignified structural armor, they easily absorb foliar sprays and require significantly lower concentrations of exogenous auxin to successfully initiate rooting.

**Mature Recalcitrance:**

In contrast, as tissue in the upper canopy undergoes a phase change prioritizing reproductive growth, it develops anatomical resistance. This includes the formation of a heavily suberized peridermis (waxy, cork-like armor) and dense sclerenchyma rings. Dr. Davies showed that this mature structural armor physically obstructs foliar absorption. Consequently, successful root initiation in mature tissue necessitates high-concentration basal applications to chemically force the auxin into the living tissue via diffusion. Attempting to overcome this structural barrier by forcing roots with a single, massive toxic dose of IBA actively decreases primordia elongation.

## APPLIED IBA TRANSLOCATION PATHWAY




Surface Entry (Dual Pathway) - input IBA through Stomata and Cuticles
Internal Transport (Phloem Highway) - primary shown going downward
Basal Root Initiation (Rooting Engine) - convert IBA to IAA for rooting

# ILLUSTRATIONS (Derived from the Studies by Drs. Cohen and Davies)

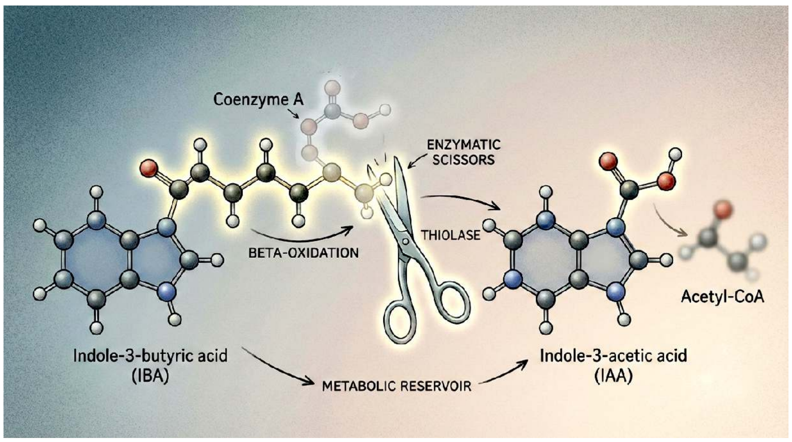
**THE CHEMICAL PROCESS IN ACTION (ß-Oxidation)**

Inspired by the representation style of Irving Geis (created by Gemini), this diagram visualizes Dr. Cohen's "Metabolic Reservoir" demonstrating the plant's controlled, slow-release mechanism for continuous auxin delivery. ("Metabolic Reservoir" is described below)

**Left (Storage):** The applied rooting product, stable Indole-3-butyric acid (IBA), enters the plant as a metabolic reservoir with a 4-carbon storage tail.

**Center (Conversion):** The enzyme Thiolase acts as molecular "scissors" cleaving the carbon bond. Grower Note: Because this enzymatic action is driven by thermodynamics, it requires adequate root-zone heating. If the media is too cold, conversion halts and the cutting stalls.

**Right (Activation):** A 2-carbon Acetyl-CoA molecule is discarded, yielding the active, naturally occurring rooting hormone: Indole-3-acetic acid (IAA).

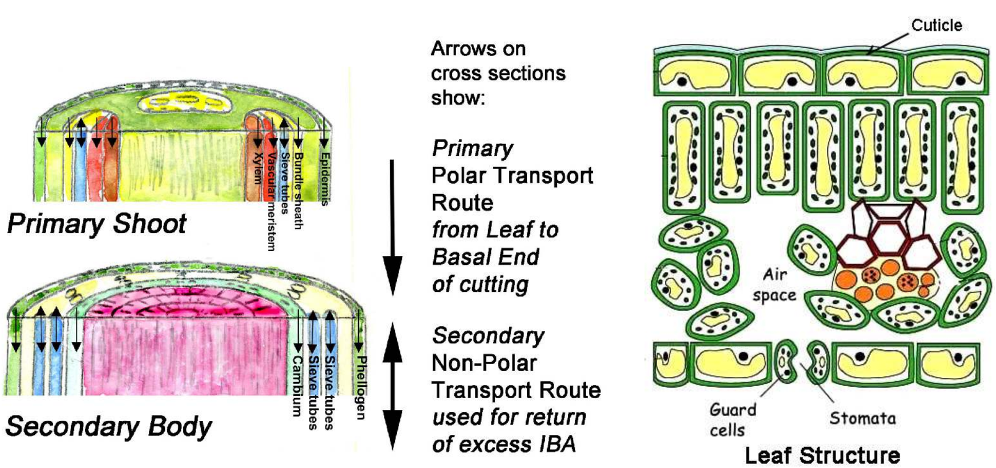



**THE PHYSIOLOGICAL DELIVERY AND STORAGE SYSTEM**

**Right, LEAF STRUCTURE (Entry):** When applying aqueous IBA via foliar methods (Spray Drip Down or Total Immerse), the solution safely bypasses outer physical barriers by utilizing a dual-pathway. It enters directly through the leaf cuticle (the waxy protective top layer) and the open stomata (the microscopic pores controlled by the green guard cells)**.**

**Left, STEM STRUCTURE (Delivery):**

- **Primary Shoot (Downward Flow):** The IBA in the solution travels downward via the Primary Polar Transport Route through the sieve tubes. This creates a highly concentrated physiological sink at the basal wound, which is stored safely as a metabolic reservoir for successful root initiation.
- **Secondary Body (Upward Return):** To prevent chemical toxicity and tissue necrosis at the wound site, the plant employs a Secondary Non-Polar Transport Route. This route works in the opposite direction (upward) to actively shunt excess IBA away from the base, maintaining a safe hormonal balance.



## PROFESSIONAL GROWER GUIDANCE & OPERATIONS

By understanding these underlying biochemical and physiological mechanisms, professional propagators can replace traditional guesswork with targeted operations.

**Facility Controls: Root-Zone Heating (Dr. Cohen's Engine):**

Because the ß-Oxidation pathway is strictly temperature dependent, it relies entirely on proper root zone heating. If the soil is too cold, the molecular scissors stop working. A cutting can be fully loaded with a massive reservoir of IBA, but if it lacks thermal energy, it will stall, forming heavy basal callus but failing to push actual roots.

**Validation of Foliar Application Methods:**

By mapping the active Polar Auxin Transport highway, Davies provided the biological justification for shifting commercial operations away from labor-intensive basal dips to highly efficient foliar sprays (e.g., Spray Drip Down, Total Immerse).

**Treating Fast-Metabolizing, Juvenile Tissue:**

Because juvenile tissue lacks restrictive bark and possesses permeable cuticles and active stomata, growers can completely skip labor-intensive basal dips. Propagators can stick unrooted cuttings directly into the media and utilize foliar methods; the plant's internal transport mechanism will safely carry the active ingredients precisely to the basal wound.

**Treating Hardwood and Dormant Material (The Two-Phase Approach):**

When forced to propagate from mature, armored stems, foliar pathways are physically blocked. Establishing roots requires a strategic two-step strategy:

**Phase 1 (Initial Basal Loading):** Growers must utilize aggressive, high-concentration solutions (typically 1000-5000+ ppm IBA) via the Basal Quick Dip method to chemically force the IBA through the tough bark via diffusion.

**Phase 2 (Sustaining the Signal):** Slow-rooting hardwood cuttings eventually deplete their initial IBA reserves. Growers can easily solve this by applying a Secondary Foliar Booster spray (Spray Drip Down) to seamlessly refill the reservoir without uprooting the cutting.

## DIAGNOSING PROPAGATION EFFECTS AND STRATEGIC TREATMENTS

Success or failure in propagation can often be diagnosed and corrected by looking at underlying biological rules. By understanding these rules, growers can intentionally manage their stock:

**Preventative Stock Plant Management:**

Before problems arise, propagators can intentionally prune (stool) mother plants to force new shoot emergence exclusively from the Cone of Juvenility. Harvesting these unarmored cuttings allows growers to bypass basal treatments and rely entirely on low-concentration foliar applications.

**Seasonal Variation (Timing Issues):**

Many plants have a strictly limited physiological window for successful rooting. Growers must align propagation schedules with the optimum, natural metabolic cycles of the specific species.

**Maturity Blockage & Recalcitrant Wood (Result: No Roots):**

If a cutting exhibits no roots, the IBA solution trial rate was likely too low to penetrate the physical armor of the mature tissue. To successfully propagate mature wood, growers must shift entirely to high-concentration Basal Quick Dips to forcefully breach the suberized peridermis via chemical diffusion.

**Mitigation of Toxicity:**

The biological discovery of the metabolic reservoir explains why propagators can safely apply high concentration doses of IBA to recalcitrant cuttings without causing localized tissue burn. The plant acts as its own regulator, slowly converting what it needs and shunting the excess away.

**Metabolic Depletion (Result: Heavy Callus, No Roots):**

If a plant successfully absorbs the IBA but forms heavy callus with no actual roots, it has completely depleted its metabolic reservoir on the initial wound response before roots could fully differentiate. Applying a secondary Foliar Spray Drip Down (booster) seamlessly refills the depleted reservoir and restarts the rooting engine without requiring the physical extraction of the cutting, protecting fragile vascular connections.

# SECTION 12 CONCLUSION

## TECHNOLOGY TO IMPROVE PLANT PROPAGATION

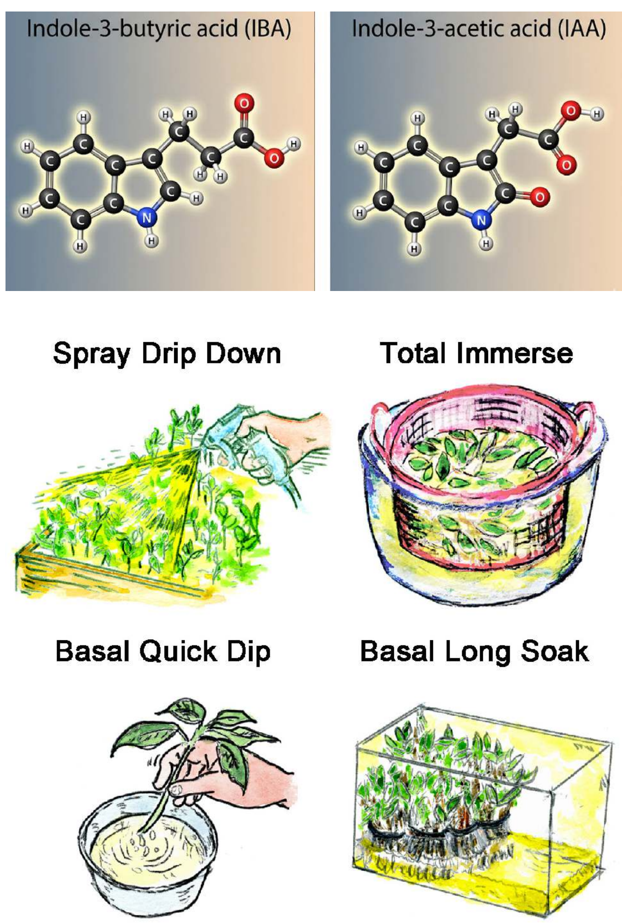
For the professional plant propagator, the ultimate objective is consistently producing the finest quality finished plants while simultaneously reducing labor, material costs, and operational overhead. Achieving this high-yield success is not a matter of chance; it is the direct result of aligning critical elements:

- The Biology: The physical histology and active metabolic physiology of the plant.
- The Chemistry: The stable, aqueous delivery of the IBA auxin.
- The Method: The specific application technique (e.g., Spray Drip Down, Total Immerse, Basal Dip, or Basal Long Soak) chosen to perfectly match the plant's anatomical structure.
- The Facility: The precise operational control of the propagation environment, including root-zone heating, misting, and humidity.
- The Discipline: The technical execution, timing, and consistency of the grower.

The introduction of Hortus IBA Water Soluble Salts fundamentally elevated the industry standard. Plant production was finally able to move away from detrimental, alcohol-based quick dips in favor of safe, essential aqueous (water-based) IBA solutions. With this product advancement, growers gained access to a highly versatile suite of application methods: the foliar Spray Drip Down and Total Immerse, alongside the basal Quick Dip and Long Soak.

Applying the foundational research of Dr. Jerry Cohen and Dr. Frederick Davies transforms propagation from traditional guesswork into a disciplined science. When propagators perfectly match the delivery method to the physical anatomy (histology) and metabolic engines (physiology) of the cutting, they can directly utilize the plant's own natural transport systems. Ultimately, this seamless alignment between chemistry and biology reduces labor, improves worker safety, and ensures the consistent production of the highest-quality finished crops.

**Below: Science to Practice**



# SECTION 13 GLOSSARY AND REFERENCES

## GLOSSARY OF TERMS

**β-Oxidation (Peroxisomal β-Oxidation):**
A temperature-dependent enzymatic process within plant cells acting as the biological engine for root formation. It systematically uses enzymes as "chemical scissors" to convert stable, stored aqueous IBA into the immediately active rooting hormone, IAA. If the propagation media is too cold, the conversion halts and the plant cannot utilize the applied hormone.

**Basipetal vs. Acropetal Transport:**
Basipetal transport is the strict, one-way downward flow (from shoot tip to basal end) utilized by active IAA and the primary Polar Auxin Transport (PAT) system. Acropetal transport is the upward flow. In the event of oversaturation at the basal sink, the plant utilizes a secondary non-polar route to shunt excess stable IBA acropetally (upward) to autonomously mitigate chemical toxicity.

**Clone (Clonal):**
A plant, or a population of plants, that is genetically identical to a single parent (the stock or mother plant). Vegetative propagation, the practice of taking severed, unrooted cuttings and stimulating adventitious root formation, is the primary method of clonal reproduction.

**Cone of Juvenility:**
Mapped by Dr. Frederick Davies, this is a highly sensitive physiological zone at the base of a stock plant's stem. Unlike the mature upper canopy, this basal tissue remains in an active, vegetative state and lacks heavily lignified bark. Because these cells retain high plasticity, they require significantly less exogenous auxin to form roots. Growers can safely use lower concentrations of aqueous Hortus IBA Water Soluble Salts via foliar methods.

**Indole-3-butyric acid (IBA) vs. Indole-3-acetic acid (IAA):**
IBA is a safe, stable precursor hormone that naturally resists immediate enzymatic destruction and photo-oxidation. It serves as the plant's stored metabolic reservoir. IAA is the free, active rooting hormone. Pure IAA is highly volatile and rarely used commercially because the plant possesses endogenous IAA-oxidases that actively destroy it to prevent toxicity.

**Mature Recalcitrance:**
The anatomical and structural resistance found in mature plant tissue, particularly in the upper canopy after a phase change prioritizing reproductive growth. These tissues develop a heavily suberized peridermis (waxy, cork-like armor) and dense sclerenchyma rings that physically obstruct the foliar absorption of weak aqueous IBA solutions. This necessitates high-concentration basal applications to chemically force the auxin into the living tissue.

**Metabolic Reservoir:**
A plant's natural ability to safely store the stable hormone precursor, IBA, within its tissues for future use (Dr. Cohen). Acting like a biological battery, this reservoir prevents chemical toxicity by allowing the plant to convert stored IBA into active IAA at its own self-regulated pace. This allows propagators to apply relatively high concentration IBA Quick Dips to mature cuttings without tissue burn.

**Physiological Sink:**
The localized area created at the basal wound after a cutting is physically excised from the stock plant. Because the continuously translocated auxin can no longer exit the stem, it pools at this biological roadblock, creating the intense chemical pressure necessary to stimulate cambial activity, drive cellular dedifferentiation, and initiate root primordia.

**Polar Auxin Transport (PAT):**
Mapped by Dr. Davies, PAT is the plant's active, unidirectional vascular highway. It translocates auxins strictly downward from apical shoots and leaves to the basal wound, eliminating the need for manual basal dipping. This downward transport dictates the efficiency of modern foliar applications.

**Thiolase ("Chemical Scissors"):**
This is the specific enzyme utilized during Peroxisomal β-Oxidation. Once the carbon chain of the IBA molecule is weakened Thiolase cleanly cleaves off two carbon atoms (discarding an Acetyl-CoA molecule) to yield the free, active IAA required for root formation. (Shown in the Illustration) .

## REFERENCES

The author thanks Dr. Frederick Davies for his contribution of current research on solution foliar entry.

**Aris Horticulture (Green Leaf Plants). Perennial** Propagation and Crop Leveling Protocols.
- Validates the operational use of aqueous IBA foliar sprays to successfully "level" highly varied crops. It demonstrates that foliar applications ensure uniform root initiation across the board, which is critical for scheduling diverse perennial crops.

**Ball FloraPlant.** "Essential Factor: Rooting Hormones." Official Cultural Guidelines.
- Recommends post-sticking foliar spray applications for commercial unrooted cuttings (URCs), explicitly citing Hortus IBA Water Soluble Salts as the industry standard for this highly efficient method.

**Cohen, J. D. (2014).** Auxin input pathway disruptions are mitigated by changes in auxin biosynthetic gene expression in Arabidopsis. Plant Physiology.
- Confirms that the conversion of IBA to IAA is a highly regulated biological system fundamental to hormonal homeostasis. It establishes Metabolic Reservoir, proving that plants sequester stable IBA to resist rapid enzymatic degradation and photo-oxidation. This mechanism prevents the detrimental "Flash Effect" associated with pure IAA, ensuring a slow, sustained release of the active rooting signal.

**Davies, F. T., Jr. (1978)**. A Histological and Physiological Analysis of Adventitious Root Formation in Juvenile and Mature Cuttings of Ficus pumila L. (Doctoral dissertation). University of Florida.
- Identifies histological barriers (suberization and sclerenchyma rings) in mature stock that physically impede rooting, contrasting them with the high sensitivity of the juvenile cone. Crucially, it provides the scientific framework for many secondary foliar applications; it proves that mature tissues require sustained chemical pressure over time, but warns that applying a single, massive dose of IBA reduces root quality and elongation, necessitating a repeated, safely timed booster approach.

**Davies, F.T. (1984)**. Shoot RNA, cambial activity and indolebutyric acid effectivity in seasonal rooting of juvenile and mature Ficus pumila cuttings. Physiologia Plantarum 62: 571-575.

**Davies, F. T., Jr., & Joiner, J. N. (1980).** Growth regulator effects on adventitious root formation in Ficus pumila. Journal of the American Society for Horticultural Science, 105, 91-95.
- Validates the mechanism of Foliar Application, proving that auxin is actively absorbed through stomata and translocated to the basal wound. It maps the plant's internal Polar Auxin Transport system, demonstrating exactly how foliar treatments travel down the phloem to create a concentrated "physiological sink" at the wound site, directly validating the efficacy of labor-saving methods like Spray Drip Down.

**Davies, F.T., J.E. Lazarte, and J.N. Joiner. (1982).** Initiation and development of roots in juvenile and mature leaf bud cuttings of Ficus pumila L. American Journal of Botany 69: 804-811.

**Dümmen Orange.** Rooting Protocols and Internal Trials on Osteospermum.
- Provides detailed rooting protocols for high-volume crops. Dr. Hammer’s internal trials scientifically demonstrate the high efficacy of multiple treatments. The trials proved that two-time foliar applications at an effective IBA rate (100-300 ppm IBA) 1 to 2 days post-sticking maximized root mass, while warning that incorrect dosing slows root formation.

**Eichert, T., and Burkhardt, J. (2001).** Quantification of stomatal uptake of ionic solutes using a new cultivation system. Journal of Experimental Botany 52(357): 771-781.
- Provides the modern proof of the Hydraulic Activation of Stomata under high humidity.

**Epstein, E., Chen, K. H., & Cohen, J. D. (1989).** Identification of indole-3-butyric acid as an endogenous constituent of maize kernels and leaves. Plant Growth Regulation, 8, 215-223.
- Proves IBA is a natural, endogenous compound, not strictly synthetic. This discovery shatters the "synthetic myth" and validates that commercial applications of water-soluble IBA do not force an unnatural chemical reaction, but rather efficiently supplement the plant's own biological machinery for safely storing and processing rooting hormones.

**Hortus USA. (2020).** Plant Propagation from Cuttings: A Guide to Using Plant Rooting Hormones by Foliar and Basal Methods (3rd ed.). http://rootinghormones.com/propagationbook.htm
- Plant propagation from cuttings is the most effective way to clone plants that are identical to the stock plant.

**Hortus USA. (2020).** Use Rooting Hormones, or Not? Multiple applications may be best. http://rootinghormones.com/propagationbook.htm
- Introduces growers to Hortus IBA Water Soluble Salts Rooting Solutions and Methods, giving up-to-date plant propagation techniques from cuttings.

**Schönherr, J., and Bukovac, M. J. (1972).** Penetration of stomata by liquids: dependence on surface tension, wettability, and stomatal morphology. Plant Physiology 49(5): 813-819.
- Supports Davies cuticular dominance and surface tension rules.

**Strader, L. C., et al. (2010).** Conversion of endogenous indole-3-butyric acid to indole-3-acetic acid drives cell expansion in Arabidopsis seedlings. Plant Physiology, 153, 1577-1586.
- Defines the chemical mechanism of Peroxisomal ß-Oxidation. It details the exact "engine" the plant uses to utilize its metabolic reservoir: a temperature-dependent, enzymatic cleavage that slowly shortens the 4-carbon butyric chain of IBA into the highly active 2-carbon acetic chain of IAA, acting as the plant's own internal regulator to safely control the pace of root initiation.

**Svenson, S.E., Davies, F.T. Jr., and Duray, S.A. (1995).** Gas exchange, water relations and dry weight partitioning during root initiation and development of poinsettia cuttings. Journal of the American Society for Horticultural Science 120: 454-459.

**Syngenta Flowers.** "Grower Culture Guides for Vegetative Unrooted Cuttings."
- Mandates an overhead heavy spray (penetrating the rooting media) using aqueous solutions at 250-300 ppm IBA, 24-48 hours after sticking. Crucially, the guide explicitly warns growers against the phytotoxic risks of using traditional alcohol-based IBA solutions as overhead applications.

# TABLE OF CONTENTS

# Index

# Summary: Optimizing Plant Production Through Science

**The Science**

Success in plant propagation relies on selecting methods, and the proper IBA solution, grounded in the science of plant physiology rather than older trial and error. Modern propagation replaces guesswork by leveraging the biological science mapped by Dr. Frederick Davies and Dr. Jerry Cohen.

By abandoning harsh, outdated solvent dips and integrating foundational research, growers can use effective modern methods to control a plant's natural transport and conversion systems to optimize facility usage and reduce costs. When aqueous IBA rooting solutions are applied to leaves, the solution safely bypasses outer physical barriers, entering directly through a dual pathway of continuous cuticular diffusion and hydraulic stomatal activation. Driven by Polar Auxin Transport, the plant actively translocates the IBA downward to the basal end of the cutting. The plant safely stores the applied stable IBA in a metabolic reservoir. Through a temperature dependent process called Peroxisomal beta-Oxidation, enzymes systematically cleave carbon atoms from the IBA chain, converting it into the active IAA needed to trigger root formation at a self-regulated pace.

**The Product**

**Hortus IBA Water Soluble Salts** are used to safely deliver IBA without harmful solvents. This dry powder dissolves in ordinary water to create a safe, EPA-registered IBA, used to produce K-IBA aqueous solutions of any needed concentration. It boasts an indefinite shelf life when stored correctly and features a zero-hour Restricted Entry Interval to maximize worker safety.

**The Methods**

Aligning the application method to the plant tissue's physiological maturity is critical for successful root formation. For sensitive, actively growing leafy cuttings, foliar applications perfectly mimic natural transport systems, safely loading the metabolic reservoir without risking solvent burn.

**Foliar IBA solution applications** are used on leafy cuttings in the growing state. The methods save labor.

- **The Spray Drip Down method** involves uniformly **spraying** cuttings already stuck in propagation media until the solution drips. Since the liquid is never reused, it completely eliminates the risk of disease cross-contamination.
- **The Total Immerse method** completely **submerges** unrooted cuttings into the solution before sticking, guaranteeing that every single leaf and stem surface receives an even, consistent IBA solution application.

**Basal IBA solutions applications** are traditional for rooting of plant cuttings.

- **The Basal Quick Dip method** immerses the basal ends of cuttings into a concentrated solution for just a few seconds before sticking. This technique applies IBA directly into the vascular cambium.
- **The Basal Long Soak method** is used for cuttings placed in shallow trays of a low-concentration solution for 12 to 24 hours, utilizing natural hydraulic suction to slowly and safely pull the aqueous IBA solution into the stem.

**The Improvements**

Growers can improve rooting by applying secondary booster foliar sprays via the overhead Spray Drip Down method. These boosters safely refill the metabolic reservoir to improve crops and ensure uniform maturity across the entire batch.

**The Conclusion**

Optimizing plant propagation is about successfully using biology. By pairing aqueous IBA with the appropriate application method, propagators can eliminate costly guesswork, protect worker safety, and consistently deliver superior finished crops.

**DOWNLOAD: http://rootinghormones.com/Optimizing/Optimizing.pdf**