

Hortus

Plant Propagation from Cuttings

A Guide to Using Plant
Rooting Hormones by
Foliar and Basal Methods

Third Edition

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**A Guide to Using Plant Rooting Hormones
by Foliar and Basal Methods**

Third Edition

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with assistance from Kees Eigenraam (Rhizopon),
Cliff Hoogland (Phytotronics), and information
from Dr. Fred Davies and Bailey Nurseries

Published by



Plant Propagation from Cuttings is the most effective way to clone plants that are identical to the stock plant

Five Successful Methods

Basal Methods

Use Dry Powder Rooting Hormones:

Dry Dip Method

Use IBA Rooting Solutions:

Basal Quick Dip Method

Long Soak Method

Foliar Methods

Use IBA Rooting Solutions:

Spray Drip Down™ Method

Total Immerse Method

The World's Finest Plant Rooting Products

Rooting Solutions

IBA Rooting Solutions:

Hortus IBA Water Soluble Salts

Rhizopon AA Water Soluble Tablets

Dry Powder

Rooting Hormones

Color Coded Powders in Three Concentrations:

Rhizopon AA #1, #2 and #3

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Articles

Propagate plants from cuttings using foliar applied aqueous (water based) IBA rooting solutions.

Tips: do's and don't's

By Joel Kroin, President, Hortus USA Corp.

Presentation made at the International Plant Propagators Society (2014)

Foliar applied rooting solutions for plant propagation from cuttings: historical background and utility.

History and methods to apply rooting solutions by basal and foliar methods.

By Joel Kroin, President, Hortus USA Corp.

Presentation made at the International Plant Propagators Society (2014)

Growth regulator effects on adventitious root formation in leaf bud cuttings of juvenile and mature *Ficus pumila*

Physiology of foliar methods and their relationship to the juvenility & maturity of cuttings.

By Frederick T. Davies and J. N Joiner

J. Am. Soc. Hort. Science (1980)

Auxin application via foliar sprays

How Bailey Nurseries implemented plant propagation using foliar applied IBA rooting solutions

By Samuel Drahm, Senior Researcher, Bailey Nurseries

Presentation made at the International Plant Propagators Society (2007)

Label

Hortus IBA Water Soluble Salts

Products Used to Make Rooting Solutions

Hortus IBA Water Soluble Salts & Rhizopon AA Water Soluble Tablets are used by ALL BASAL and FOLIAR Methods and Rates (*Quick Dip, Basal Long Soak, Spray Drip Down and Total Immerse Methods.*) They replace technical IBA and K-IBA, and pre-mix rooting products, with MORE applications.

Both products contain the water soluble active ingredient: Indole-3-butyric acid (IBA).

Hortus IBA Water Soluble Salts® (20%)



- **Measure** Hortus IBA Water Soluble Salts using a scale then mix into ordinary water.
- Hortus IBA Water Soluble Salts are water soluble to OVER 100,000 ppm IBA, remain in solution at any concentration.

Rhizopon® AA Water Soluble Tablets



- **Count** Rhizopon AA Water Soluble Tablets then mix into ordinary water.
- Rhizopon AA Water Soluble Tablets are water soluble to 1500 ppm IBA.

Products Used by the Basal Dry Dip Method

Rhizopon AA #1, #2 and #3 Dry Dip Rooting Hormones are always ready to use by the Basal Dry Dip Method.

Rhizopon® AA #1 (0.1)

- Active Ingredient 0.1% Indole-3-butyric acid (IBA)
- **Color identified Pink Color Powder.**
- Use on easy to root cuttings.

Rhizopon® AA #2 (0.3)

- Active Ingredient 0.3% Indole-3-butyric acid (IBA)
- **Color identified Green Color Powder.**
- An intermediate all purpose product.
- Use on easy to more difficult to root cuttings.

Rhizopon® AA #3 (0.8)

- Active Ingredient 0.8% Indole-3-butyric acid (IBA)
- **Color identified White Color Powder.**
- Use on more difficult to root cuttings.



Foliar Methods

Use Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets to Make Rooting Solutions



SPRAY DRIP DOWN™ METHOD

- Stick cuttings.
- Spray the Rooting Solution onto leaves until drip down.



TOTAL IMMERSE METHOD

- Total immerse the cuttings a few seconds in the Rooting Solution.
- Drain.
- Stick cuttings.

Basal Methods



BASAL QUICK DIP METHOD

- Immerse basal end of cuttings a few seconds in the Rooting Solution.
- Stick cuttings.



BASAL LONG SOAK METHOD

- Immerse basal end of cuttings a few hours in the Rooting Solution.
- Stick cuttings.

Use Rhizopon AA #1, #2 and #3 Dry Dip Rooting Hormones



DRY DIP METHOD

- Dip basal end of cuttings in the Rhizopon AA rooting powder.
- Stick cuttings.

Questions you want to ask when reading this book

About the Products

How much Hortus IBA Water Soluble Salts do I need?

- A Rooting Solution, for one gallon at 1000 ppm, uses 19 grams of Hortus IBA Water Soluble Salts.
- By the Basal Long Soak and Basal Quick Dip Methods one gallon of Rooting Solution can treat many thousand cuttings.
- By the Spray Drip Down Method one gallon of Rooting Solution can treat 175-225 square feet of propagation trays.
- For typical use, at 100 ppm IBA, annual cuttings use 1.9 grams of Hortus IBA Water Soluble Salts per gallon.

Can I make a concentrated stock mix?

Rooting Solutions made with Hortus IBA Water Soluble Salts can be made to over 100,000 ppm IBA using ordinary water. Growers can make up concentrated Rooting Solutions in the production office. The concentrated Rooting Solution can be added to the production tank in the work area then add water to bring the solution to full rate.

What is the keeping life of a Hortus IBA Water Soluble Salts Rooting Solution?

- An un-used Rooting Solution can be used for several days after make-up if stored at normal room temperature and light. Solutions made for the Spray Drip Down Method are un-used until sprayed. (See pages 16-17 for solution notes.)
- The Total Immerse, Basal Long Soak and Basal Quick Dip Methods use the Rooting Solution on each treated plant lot. Dispose used Rooting Solutions between production lots to avoid cross contamination.

What is the keeping life of dry Hortus IBA Water Soluble Salts, Rhizopon AA Water Soluble Tablets and un-used Rhizopon AA dry powder rooting hormones?

Un-used, DRY, in the original container, sealed, and at room temperature, the products retain potency for many years. Refrigeration is not required. Do NOT allow the powders to become damp or wet. (See pages 16-17 for notes.)

What is the cost of Hortus IBA Water Soluble Salts compared with so called 'pre-mix' rooting products? How is Hortus IBA Water Soluble Salts different from a pre-mix?

- Hortus IBA Water Soluble Salts cost about 1/3 to 1/5 the price of 'pre-mix' rooting solutions.
- Hortus IBA Water Soluble Salts can be shipped by ordinary means. 'Pre-mix' rooting solutions can incur 'hazardous shipping charges'.
- Hortus IBA Water Soluble Salts Rooting Solutions are made by the grower using ordinary water; the Rooting Solutions can never cause solvent toxicity. Alcohol based 'pre-mix' rooting solutions may cause alcohol toxicity to the cuttings especially at high concentrations.
- 'Pre-mix' contain un-needed ingredients; NAA in them has little plant need and not used by European growers.

Hortus IBA Water Soluble Salts & Rhizopon AA Water Soluble Tablets, dissolved in water, make IBA and KIBA rooting solutions for all applications.

What is the difference between Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets and technical IBA/KIBA?

Hortus IBA Water Soluble Salts & Rhizopon AA Water Soluble Tablets make IBA and KIBA rooting solutions used for all basal and foliar methods.

Hortus IBA Water Soluble Salts, Rhizopon AA Water Soluble Tablets, and **Rhizopon AA dry powers** are registered with the US EPA for use by plant growers.

Hortus IBA Water Soluble Salts make solutions to over 100,000 ppm IBA/KIBA. **Rhizopon AA Water Soluble Tablets** make solutions to over 1500 ppm IBA/KIBA.

The US EPA **does not permit** technical IBA and KIBA to be used by plant growers; **none** are labeled for any use by plant growers. IBA can only be dissolved in **dangerous solvents**. KIBA, dissolved in water, is **unstable**; both IBA and KIBA drop out of solution at nominal ppm's.

What is the WPS re-entry interval (REI) for Hortus IBA Water Soluble Salts and Rhizopon AA products?

Hortus IBA Water Soluble Salts and all Rhizopon AA products have US EPA labels with ZERO hour REI. After sticking and treating, workers and handlers can enter the growing area any time without PPE.

How do I select Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets?

Both products are used in both foliar and basal methods.

Hortus IBA Water Soluble Salts:

- **Measured using a scale;** useful where large production tanks are used.
- Useful when growers require high concentrations.

Rhizopon AA Water Soluble Tablets:

- **Measured by counting tablets;** useful where a scale is not available.
- Useful when growers require low concentrations or small liquid volumes.

About the Rooting Solution Methods

Why would I want to use ‘Foliar’ compared to ‘Basal’ Rooting Solution methods?

Foliar methods are used on leafy plants in the growing season. Basal methods are used all year. Foliar methods treat cuttings uniformly. Basal Quick Dip Method may have variable treatment. **Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble tablets are used by the Quick Dip Method and all Foliar methods, but Quick Dip uses more labor.**

When can I turn on misters after treating by the Spray Drip Down Method?

Growers usually wait 3/4 hour or until the Rooting Solution dries on the leaves.

Is special equipment needed for foliar methods?

The Spray Drip Down Method uses standard spray equipment such as backpacks, hydraulic, booms, tractor mounted sprayers, robots, hand sprayers, and custom spray carts specific to needs. The Total immerse Method uses a simple tank and strainer.

About the Dry Dip Rooting Hormones & Comparison with Rooting Solutions

How many cuttings can be treated using Rhizopon AA dry powders?

One pound of Rhizopon AA dry powder rooting hormones can treat about 30,000 cuttings.

Is there a difference in rooting between using 'Rooting Solutions' or 'dry powder rooting hormones'?

Hortus USA sells both dry powder rooting hormones and products to make water based IBA rooting Solutions, both ways are beneficial. Growers usually have long standing preferences. Use should be based upon the variety, time of the year, maturity of the cuttings and quality of the stock plants. Many US growers prefer Rooting Solutions, while some European growers prefer Dry Dip powder rooting hormones.

How are Rhizopon AA dry powder rooting hormones different from other brand dry powder rooting products?

Rhizopon AA #1, #2 and #3 are made with high loft talc resulting in uniform coverage of the treated cutting. The powders are color coded to identify the product: **Rhizopon AA#1 is pink**, **Rhizopon AA#2 is green** and **Rhizopon AA#3 is white**. Color coding helps the production workers to pick and use the proper product. All production lots are laboratory tested to assure they have uniform mix and meet the required concentration.



Fine quality roots produced by Bailey Nursery using the Spray Drip Down Method

Why do I need rooting hormones to propagate 'easy-to-root' cuttings?

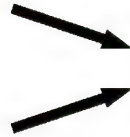
Cuttings require applied IBA rooting hormones to rapidly produce high root mass, with uniform roots and upper growth.



Hortus IBA Water Soluble Salts

Water Soluble to Over
100,000 ppm IBA

ROOTING
SOLUTIONS
MADE USING
ORDINARY
WATER



Rhizoapon AA Water Soluble Tablets

Pre-measured - Count and Mix

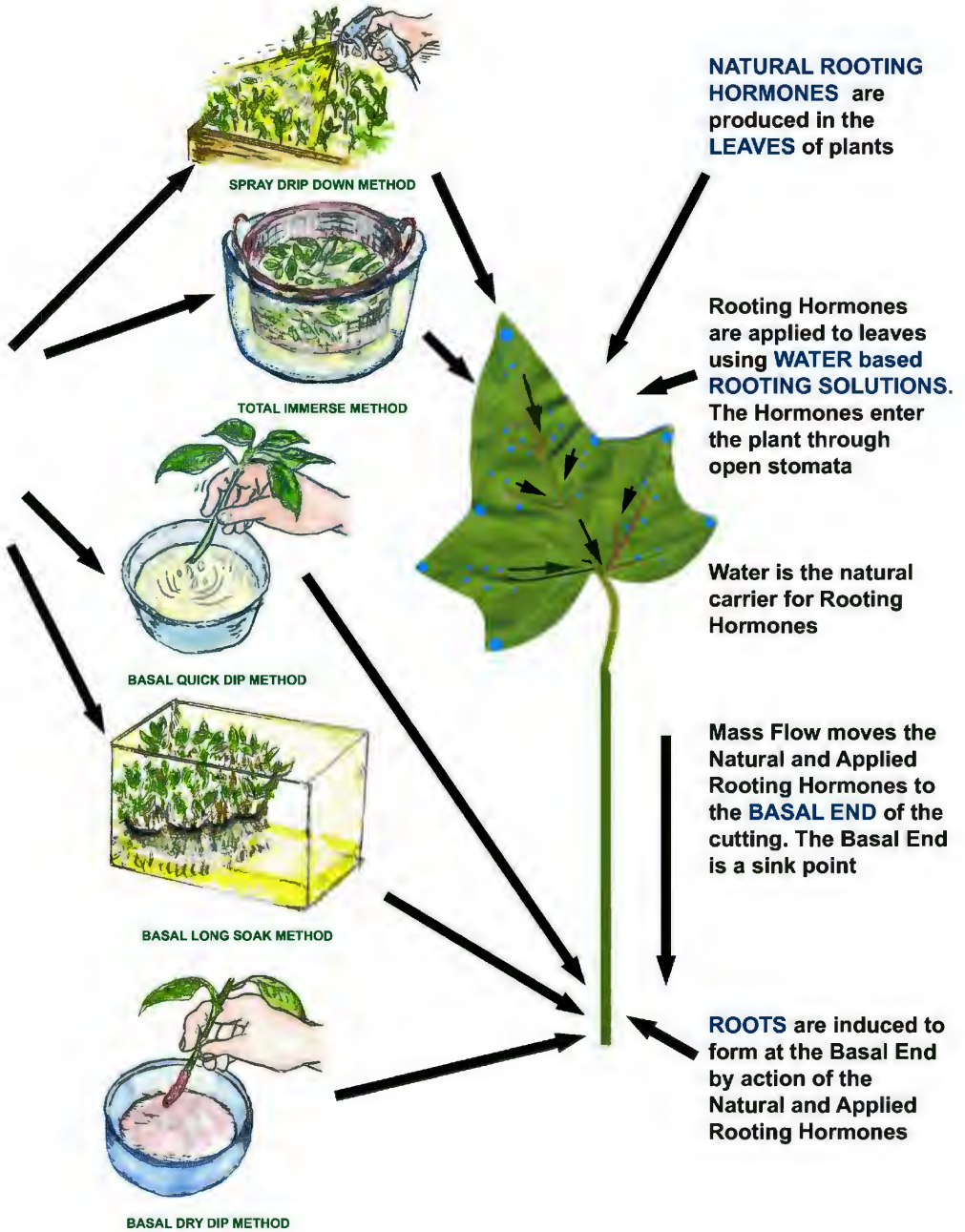


Rhizoapon AA Dry Powder Rooting Hormones

READY
TO USE
DRY
POWDER
ROOTING
HORMONES



The Most Popular Concentrations



Methods to Propagate Plants from Cuttings

Cutting Types and Methods

USE ON TYPE OF CUTTINGS	Dry Dip	Basal Quick Dip	Basal Long Soak	Spray Drip Down	Total Immerse
LEAFY CUTTINGS <ul style="list-style-type: none"> • Ornamental plants • Herbaceous plants <i>In the Growing Season</i>	✓	✓	✓	✓	✓
LEAFLESS CUTTINGS <ul style="list-style-type: none"> • Ornamental plants • Herbaceous plants <i>All Year Including Winter Cuttings</i>	✓	✓	✓	no (leafless)	no (leafless)
<ul style="list-style-type: none"> • EASY-TO-ROOT • HARD-TO-ROOT <i>Dormant in the Winter</i>	✓	✓	✓	no (dormant)	no (dormant)

Basal and Foliar Methods

METHOD		PRODUCT TYPE	PRODUCT
BASAL METHODS	DRY DIP METHOD	<p>Dry Dip Powder</p> <p>Dip basal end in rooting powder then stick. <i>Powders stay on cuttings a long time.</i></p>	<p>RHIZOPON AA #1, #2 & #3</p> <p>Dry Powder Rooting Hormones <i>Use dry > not used to make rooting solutions</i></p>
	BASAL QUICK DIP METHOD	<p>Rooting Solution</p> <p>Dip basal end in rooting solution then stick.</p>	<p>HORTUS IBA WATER SOLUBLE SALTS</p> <p><i>or</i></p> <p>RHIZOPON AA WATER SOLUBLE TABLETS</p> <p><i>Use to make rooting solutions</i></p>
	BASAL LONG SOAK METHOD	<p>Rooting Solution</p> <p>Dip basal end of cuttings in rooting solution about 12 to 48 hours (nominal) then stick.</p>	
FOLIAR METHODS	SPRAY DRIP DOWN METHOD	<p>Rooting Solution</p> <p>Stick then spray leaves of cuttings with rooting solution until the solution drips down.</p>	
	TOTAL IMMERSE METHOD	<p>Rooting Solution</p> <p>Totally immerse cuttings in rooting solution then stick.</p>	

Using Rooting Solutions made with Hortus IBA Water Soluble Salts

PREPARING A ROOTING SOLUTION

- **Weigh** the required amount of Hortus IBA Water Soluble Salts. **Measure by weight not volume: do not scoop.**
- **Use tap water** from 60F to about ~110F (water temperature used for hand washing). At higher temperature Salts dissolve fastest. (See pages 16-17 for handling). **Do not dissolve Hortus IBA Water Soluble Salts in liquids other than water.**
- **Mix:** dissolve Hortus IBA Water Soluble Salts in water.
- **Add water** to the mixing container to bring the Rooting Solution to the final volume.
- **Apply the solution** by the selected method.
- **After use,** dispose of the solution as described in the 'Storage and Disposal' statements on the product label.

AVOID CROSS CONTAMINATION OF SOLUTIONS

- For the Total Immerse, Basal Quick Dip and Basal Long Soak Methods dispose of Rooting Solutions between plant lots to avoid cross contamination.
- Using the Spray Drip Down Method the Rooting Solution is used one time and there is no cross-contamination. Solutions can be used completely. (See pages 16-17 for handling).

STOCK SOLUTIONS

Hortus IBA Water Soluble Salts mixed in water to make stock Rooting Solutions can be made in any concentration up to 100,000 ppm IBA!

USE METRIC SYSTEM

Use the metric system when calculating the ppm IBA for Hortus IBA Water Soluble Salts Rooting Solutions. The system allows for easy calculation of liquid volume to concentration.

NO WETTING AGENTS

Rooting Solutions made with Hortus IBA Water Soluble Salts are specially formulated to have a low surface tension needed for foliar methods. Additional wetting agents are not recommended.

Rooting Solution Rate Chart: Hortus IBA Water Soluble Salts

To make 100 ppm IBA dissolve 0.5 grams in 1 liter water

Parts per million IBA (ppm IBA)	Hortus IBA Water Soluble Salts	
	gms/liter water	gms/gallon water (1 gal = 3.8 liter)
50 ppm IBA	0.25 grams	.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
MAKE ANY RATE		
100,000	500	1900

Using Rooting Solutions made with Rhizopon AA Water Soluble Tablets

- Count the required amount of Rhizopon AA Water Soluble Tablets as shown in the chart below.
- Use tap water from 60F to about ~110F (water temperature used for hand washing). At higher temperature the Tablets dissolve fastest. (See pages 16-17 for handling.) **Do not dissolve Rhizopon AA Water Soluble Tablets in liquids other than water.**
- Mix: dissolve Rhizopon AA Water Soluble Tablets in the water. A small amount of undissolved particles in the solution is normal and does not affect results. If precipitation occurs with tap water then dissolve in distilled, demineralized, or filtered water. Add water to the mixing container to bring the solution to the final volume.
- Apply the solution by the selected method.
- After use: See pages 16-17 for handling and disposal.
- Avoid cross contamination of solutions. For the Total Immerse Method and basal methods, dispose of solutions between plant lots to avoid cross contamination. Using the Spray Drip Down Method the solution is used one time and there is no cross-contamination.

Rooting Solution Rate Conversion Chart:

Parts per million IBA (ppm IBA)	Rhizopon AA Water Soluble Tablets per liter water	Hortus IBA Water Soluble Salts	
		gms/liter water	gms/gallon water (1 gal = 3.8 liter)
50 ppm	1 tablet	0.25 grams	0.95 grams
100	2	0.5	1.9
200	4	1.0	3.8
300	6	1.5	5.7
400	8	2.0	7.6
500	10	2.5	9.5
600	12	3.0	11.3
700	14	3.5	13.2
800	16	4.0	15
900	18	4.5	17
1,000	20	5.0	19

Handling Dry Products & Rooting Solutions

STORAGE OF DRY PRODUCTS

- Rhizopon AA #1, #2 & #3 Dry Dip Rooting Hormones, Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets are provided dry. Store dry products at room temperature. They do not require refrigeration. The dry products will be fully active for many years.
- Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets are sensitive to humidity. Store them dry to avoid caking and difficulty to dissolve.
- ***Store the dry products in their original sealable labeled containers.***

ROOTING SOLUTION WATER QUALITY

- Ordinary tap water is usually used to make Rooting Solutions.
- If the Rooting Solution is clear, having a small amount of particles, then the active ingredient is in solution and ready to use.
- Hard, well or pond water may reduce solubility; in those cases use another source such as filtered or demineralized water.

AVOID CONTAMINATION OF SOLUTIONS

- The **Spray Drip Down Method** uses the Rooting Solution one time. Since no plant material is introduced to the solution, they will not be contaminated by dragging-in of organic materials. (See page 17.)
- The **Basal Quick Dip, Total Immerse, and Basal Long Soak Methods** use the Rooting Solution by having the plant material dipped into them. To avoid cross-contamination, use fresh Rooting Solutions between production lots. Preferably, solutions used by dipping should be disposed after four hours of use. Do not store used solutions. (See page 17.)

STORAGE OF UN-USED ROOTING SOLUTIONS:

- Stock and production Solutions made with Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets maintain full potency for several days when kept in a closed container, at room temperature and normal light. (See page 17 for disposal.)

DIP SOLUTION DISPOSAL

The following on 'disposal' may be applied to any solution where plant material is dipped and further used. After initial dipping the solution, drag-in of contaminants from the plants can be detrimental to further lots. (Spray Drip Down Method solutions do not become contaminated, they are not used by dipping.)

Solutions used to dip plant material can cross contaminate production lots by pathogens and other toxicities including chemical pre-treatments before use of the rooting solution. Before rooting hormone treatment and sticking, plant cuttings should be washed. Cutting from plantations have been pre-cleaned but need inspection. Rooting solutions for dipping are used by the basal Quick Dip, Basal Long Soak and Total Immerse Methods.

It is important to identifying plant cuttings that can cause phytotoxicity cross-contamination. Cuttings arriving from carefully inspected plant plantations may have low possibility for phytotoxicity problems. Cuttings taken from general field stocks have high possibility for phytotoxicity problems. Homogenous cuttings, taken from the same stock area, should be considered to have assumed some cross-contamination. Dip solutions used for these cuttings should be disposed after the production lot is completed. Solutions that show visible particulates should be disposed and replaced before treating the next plant lot.

Solutions made with Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets remain active during the short term treatment process. Dip solutions should be disposed after treating large homogenous lots. For well inspected cuttings with low possibilities of contamination, dispose solutions should be within four hours after the start of dip treatments.

Simple Tip to PRE-MEASURE SALTS:

RE-USE EMPTY CONTAINERS

To batch measure DRY Hortus IBA Water Soluble Salts and save for later, save empty Hortus IBA Water Soluble Salts containers with original covers and labels. If a particular powder weight is used for production tank loads, measure that amount. Put the weighed powder into the re-used empty containers. Cover securely. Mark the containers with the weight and save to make solutions later.

Overview of Foliar Methods

- **The Foliar Spray Drip Down and Total Immerse Methods are used on cuttings that are leafy in the growing season.**
- Foliar methods *are not* used on dormant or leafless cuttings.
- Rooting Solutions are applied to the leaves of cuttings.
- Foliar methods use Rooting Solutions that are made using water only, applied by spray onto foliage or totally immerse.
- **For foliar methods only use Rooting Solutions made with water and Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets.** Never use other 'Rooting Solutions' made with active solvents since they will dehydrate and kill plant cells.

ROOTING SOLUTIONS PRODUCTS

- **Hortus IBA Water Soluble Salts (weigh/mix)**
- **Rhizopon AA Water Soluble Tablets (count/mix)**

MODE OF ACTION

Water-based Rooting Solutions are applied to leaves of cuttings. The Rooting Solutions enter the plant through stomata, the minute openings in the leaf. The stomata allow entry into the plant of gases and liquids such as the Rooting Solution. After entry into the vascular system of the plant, the rooting hormones in the Rooting Solution move by mass flow to the basal end of the cuttings. Plants store rooting hormones at the basal end where they are slow released to induce roots.

METHODS	PRODUCTS TO USE
TOTAL IMMERSE METHOD	Use Rooting Solutions made with Hortus IBA Water Soluble Salts <i>or</i> Rhizopon AA Water Soluble Tablets
SPRAY DIP DOWN METHOD	
Selection of either the Spray Drip Down or Total Immerse Method, usually depends upon the type of cuttings and facility needs. Where large homogenous plant lots are propagated, usually the Spray Drip Down is used. For large leaf cuttings, Total Immerse may be better.	

USE SECONDARY & SEQUENTIAL FOLIAR TREATMENTS

- Overcome slow root development
- Improve transplanting of rooted cuttings.
- Level the production crop.
- Improve roots of cuttings which were already treated by any method, either rooted or un-rooted.

To level crops, **secondary weekly** Spray Drip Down Method foliar applications are used on leafy cuttings in the active growing state, at rates similar to the first initial rate. First application may be any method.

- **Increase production of root mass**

For **sequential day** application, see the article "Propagate Plants from Cuttings Using Foliar Applied Aqueous IBA Rooting Solutions. Tips: Do's and Don'ts", topic "Sequential Treatment". (Article after the numbered pages.)

STOCK PLANT PREPARATION FOR FOLIAR METHODS

The stock plants must be adequately fertilized and kept in light during the days before the cuttings are taken. These factors allow the plant to store carbohydrates necessary for root formation.

ADJUSTING THE FOLIAR RATE

- Use as low a rate as possible to achieve rooting.
- When root formation is **slow** in formation trial at a higher rate.
- When foliar methods produce leaf spotting, leaf curl, or leaf drop it may be caused by inadequate stock plant preparation or too high a rate.

Scientific Groundwork on Foliar Applied Aqueous IBA Rooting Hormones

Dr. Fred T. Davies (co-author of 'Plant Propagation Principles and Practices') did successful plant rooting trials using foliar applied aqueous IBA solutions as related to juvenile and mature cuttings.

Included in this book: Dr. Davies' landmark study details solution rates as related to the rooting of the cuttings physiology. (Article after the numbered pages.)

The Spray Drip Down™ Method

Using the Spray Drip Down Method, stick the cuttings into trays or any other way into media. Spray the Rooting Solution onto the leaves of the cuttings until there is a drip down. Wait about 3/4 hour or until the solution dries on the leaves, then turn on misters



The Spray Drip Down Method can be used on any lot size. The solution is used one time. There can be no cross contamination of the Rooting Solution between plant lots.

The Spray Drip Down Method has low labor cost. Workers who do sticking do not apply rooting products and do not need PPE. Spraying, performed by a trained operator, assures that the plant cuttings receive a uniform application of the Rooting Solutions. The time for spraying is only a few minutes.



Typical backpack sprayer suitable for application

EQUIPMENT

Use spray equipment appropriate for the growing facility, for example, backpack, power sprayers, or even robots. Other equipment is shown elsewhere in this book. Proportional solution mixers may not give uniform solution quality.

ROOTING PRODUCTS USED

- Hortus IBA Water Soluble Salts.
- Rhizopon AA Water Soluble Tablets

HOW TO USE THE SPRAY DRIP DOWN METHOD

STICKING & SEPARATION OF LOTS BY RATE

- Stick the un-treated cuttings in the media.
- Keep the cuttings hydrated by keeping misters on.
- It is useful to separate the plants into rooting solution rate groups. Plants with the same solution rate can be treated at the same time.

ROOTING SOLUTION

- For foliar methods, only use Rooting Solutions made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. The aqueous solutions are specially formulated to allow entry into the plant's vascular system.

TREATMENT

- Spraying should be done the same day of sticking or soon after.
- Spraying should be done when the stomata in the leaves are open. If the propagation area is hot, do spraying at cool times, such as early mornings.
- Turn off the misters.
- **Spray the Rooting Solution onto leaves until the liquid drips down. If the leaves are wet from misters at the time of spraying, use an excess of Rooting Solution to overcome dilution of the solution.**
- To assure adequate treatment, apply enough solution to both the top and bottom of the leaves.

SPRAY RATE

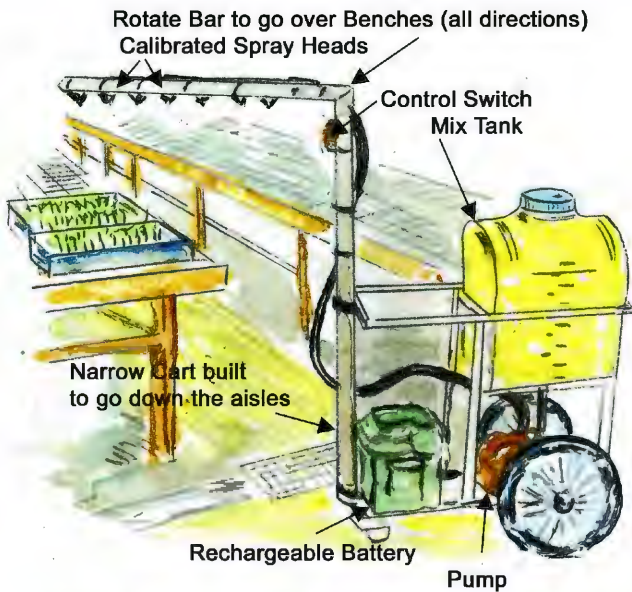
- Use about one gallon of rooting solution per 175 to 225 square foot of cuttings.

MISTERS

- **After application of the Rooting Solution wait at until the solution dries, about 3/4 hour, before turning misters on.**

UN-USED ROOTING SOLUTIONS

- **See pages 16-17 for notes**



Custom Built Cart Used to Apply Rooting Solutions by the Spray Drip Down Method



Sprayer used by Bailey Nurseries.
Photo: Bailey Nurseries

The Total Immerse Method



Using the **Total Immerse Method**, total immerse dip the cuttings in the Rooting Solution for a few second then drain. Stick at any time.

The Total Immerse Method can be used for large homogeneous lots of plants or small lots. There can be drag in of biologicals from the cuttings into the solution. The Rooting Solution should be

changed frequently to avoid lot cross contamination. Total Immerse is useful for large leaf cuttings and cuttings whose leaves have stomata on the bottom of the leaf where spray drip down is difficult to use.

The Total Immerse Method uses simple equipment for treatment, a tank and a basket. Uniform treatment is done on large batches of cuttings is done in a few seconds. Since all cuttings are submerged in the Rooting Solution every cutting is treated. After treatment the cuttings can be stored in a plastic bag and stuck later.



Hedera (Ivy) Holland. Total immerse tank for ivy.
Dip basket not shown. Photo: Rhizopon

EQUIPMENT

Use a solution tank. A dipping basket is useful.

ROOTING PRODUCTS USED

To make Rooting Solutions:

- **Hortus IBA Water Soluble Salts.**
- **Rhizopon AA Water Soluble Tablets**

HOW TO USE THE TOTAL IMMERSE METHOD

- Total Immerse the cuttings, using a basket, into the Rooting Solution for a few seconds. Drain.
- Stick the treated cuttings in the media, or put in plastic bags and store until sticking or planting out..
- Turn on misters as required.
- After treatment discard used Rooting Solution.

Overview of Basal Methods

- The Basal Quick Dip, Basal Long Soak and Basal Dry Dip Methods are used on
 - leafy cuttings in the growing season or dormant
 - leafless cuttings
 - dormant cuttings
- Basal methods can be used all year.
- Rooting Solutions or rooting hormone powders are applied to the basal end of cuttings.

ROOTING PRODUCTS USED

Dry Dip Rooting Hormones

- Rhizopon AA #1, #2 and #3.

To make Rooting Solutions:

- Hortus IBA Water Soluble Salts.
- Rhizopon AA Water Soluble Tablets.

MODE OF ACTION

Rooting Solutions or dry powder rooting hormones are applied to the basal end of the cuttings. The rooting hormones absorbed into the plant's vascular system where they are stored; they are slow released by the plant to induce root formation.

METHODS	PRODUCTS TO USE
BASAL QUICK DIP METHOD	Use Rooting Solutions made with Hortus IBA Water Soluble Salts <i>or</i> Rhizopon AA Water Soluble Tablets
BASAL LONG SOAK METHOD	
DRY DIP METHOD	Use Rhizopon AA #1, #2, or #3 Dry Dip Rooting Hormones
The selection of a method, either Dry Dip or by Rooting Solution, usually depends upon the plant variety. Many plants have successful rooting with Dry Dip methods and/or Rooting Solution methods.	

The Quick Dip Method



Using the **Basal Quick Dip Method**, propagate plants from cuttings from easy to difficult to root. Dip the basal end of the cuttings into the Rooting Solution for about five seconds then stick.

USE ON MANY TYPES OF PLANT CUTTINGS

In the Growing Season	Leafy cuttings: Tropical plants. Annual and perennial plants. Woody ornamental plants. Forestry plants.
All Year	Leafy and leafless cuttings: Tropical plants. Annual and perennial plants. Woody ornamental plants. Forestry plants.
Winter Dormant Cuttings	Leafless cuttings: Woody ornamental plants. Forestry plants.
All Year	Leafy & leafless cuttings: Hard-to-root cuttings.

EQUIPMENT

Dispense Rooting Solutions into small cups.

ROOTING PRODUCTS USED

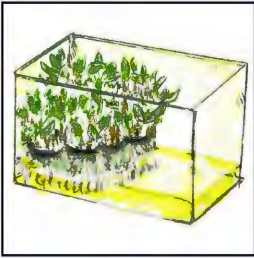
To make Rooting Solutions:

- **Hortus IBA Water Soluble Salts.**
- **Rhizopon AA Water Soluble Tablets**

HOW TO USE THE BASAL QUICK DIP METHOD

- Wound woody cuttings by making a 3/4 inch slit at the side of the basal end is optional. Herbaceous cuttings are not wounded.
- Immerse the basal end of the cuttings about 3/4-1 inch into the Rooting Solution for about five seconds.
- Stick the treated cuttings in the media, or put in plastic bags and store until sticking or planting out.
- Turn on misters as required.
- After treatment discard the used Rooting Solution.

The Basal Long Soak Method



Using the **Basal Long Soak Method**, propagate plants from cuttings that are difficult to root. It is also used on easier to root cuttings. Both hard to woody plant cuttings and herbaceous cuttings benefit. Low Rooting Solution rates are used. Basal Long Soak eliminates high rates by the Quick Dip Method rates or Dry Dip rooting powders.

In the growing season	Leafy cuttings: annuals, perennials, ornamental and forestry plants.
All year	Ornamental and forestry plants.
Winter dormant cuttings	Ornamental and forestry plants.



Dutch nursery. Stem rose propagation using the basal long soak method. Photo: Rhizopon

EQUIPMENT

Use a tank.

ROOTING PRODUCTS USED

To make Rooting Solutions:

- **Hortus IBA Water Soluble Salts.**
- **Rhizopon AA Water Soluble Tablets.**

HOW TO USE THE BASAL LONG SOAK METHOD

- Wounding of woody cuttings is optional. Herbaceous cuttings are not wounded.
- Bundle cuttings so they are erect in the tank.
- Immerse the basal end of the cuttings about 3/4-1 inch into the Rooting Solution. (See pages 26-27 for photos)
- Soak about 12-48 hours.
- Stick the treated cuttings in the media, or put in plastic bags and store until sticking or planting out.
- Turn on misters as required.
- After treatment discard the used Rooting Solution.

USE THE BASAL LONG SOAK METHOD TO IMPROVE ROOTING OF HARD-TO-ROOT CUTTINGS

When propagating plants from cuttings, if roots do not form, some growers unsuccessfully apply plant rooting hormones at high concentrations. They may use rates above 5000 ppm IBA and perhaps get variable results. If alcohol based Rooting Solutions are used they will cause burns and plant mortality.

SOLUTION

Use the basal long soak method to replace other high concentration methods.

High plant rooting hormone concentrations may inhibit root formation. For difficult to root cuttings, the Basal Long Soak Method can successfully replace the Basal Quick Dip or Dry Dip Methods. The Basal Long Soak Method uses very low concentrations of Rooting Solution.



Bundle cuttings, then immerse basal end 3/4-1 inch into the Rooting Solution for 12-48 hours, then plant or store.

MODE OF ACTION

Using the Basal Long Soak Method, cuttings slowly absorb the Rooting Solution. The plant stores the plant rooting hormones at the basal end where it slowly releases them for root formation.

TIMING

The Basal Long Soak Method is used all year on all types of cuttings. Used in the fall, cuttings can be kept in cold storage and planted out in the spring. They can also be treated before planting.

The Basal Long Soak Method is as important as ever!

Developed in the 1940's, the Basal Long Soak Method is successful for growers to propagate HARD TO ROOT CUTTINGS, as well as root stocks like grape, rose, and prunus.

The Dry Dip Method



Using the **Dry Dip Method**, propagate plants from cuttings from easy to difficult to root. **Rhizopon AA #1, #2 and #3** rooting powders are used. When treating cuttings with different rate needs, simply switch powders.

As a **VISUAL** indicator, **color coding** assures that the proper product is used.

USE ON MANY TYPES OF PLANT CUTTINGS

In the growing season.	Leafy cuttings: annuals, perennials, woody ornamental and forestry plants.
All year.	Tropical plants annuals, perennials, woody ornamental and forestry plants.
Winter dormant cuttings.	Woody ornamental and forestry plants.
All year.	Hard to root cuttings.

EQUIPMENT

Rooting powders are taken from the stock container and put into small cups. It is handy to keep three containers available for each of the three **color coded** concentrations.

ROOTING PRODUCTS USED

Dry Dip Rooting Hormones (color coded):

- **Rhizopon AA #1 (0.1% IBA) is PINK color**
for easier to root cuttings
- **Rhizopon AA #2 (0.3% IBA) is GREEN color**
for root many types of cuttings
- **Rhizopon AA #3 (0.8% IBA) is WHITE color**
for more difficult to root cuttings

HOW TO USE THE DRY DIP METHOD

- Take off a small portion of the powder for immediate use. Do not contaminate the stock container by returning used portion to the container.
- Take plant cuttings, usually 4-6 inch stem cuttings, from the current year's growth.
- Wound woody cuttings by making a 3/4 inch slit at the side of the basal end is optional. Herbaceous cuttings are not wounded.
- Dip the basal end of the cuttings 3/4-1 inch into the Rhizopon AA powder. Tap off the excess powder.
- Avoid contact between the powder and foliage and other over ground parts of the stem. A small amount of powder on the leaves will not affect the quality of the rooting.
- Stick the treated cuttings in the media, or put in plastic bags and store until sticking or planting out. A dribble hole is useful to allow entry of the cutting into the media without pushing off the rooting powder.
- Turn on misters as required.
- After treatment discard used rooting powder.



Foliar Method Trial Rates

- **Total Immerse Method**
- **Spray Drip Down™ Method**

A wide solution trial rate range is indicated for the Total Immerse and Spray Drip Down Methods. Ideal rates will vary according to specific plant variety, season, quality of the cuttings, and local growing conditions. Prior to large scale production, test a few plants at several rates within the range. If foliar application causes phytotoxicity, try basal applications and/or decrease rates. Use the lowest rate to produce the desired effect.

TYPICAL SPRAY DRIP DOWN METHOD™
SOLUTION USE: 175-225 sq. ft./gallon

Trial rates are *ppm* IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets (see pages 14-15 for conversion charts)

CUTTING TYPES	Hortus IBA Water Soluble Salts (<i>ppm</i> IBA)
Annuals, perennials, chrysanthemum	50-250
Herbaceous and hard to root perennial plant cuttings	250-1500
Woody ornamental cuttings	300-1500



Plant cuttings vary in quality. Trial rates shown are from specific lots under the grower's particular faculty and environmental controls. Growing facility and plant lots are different; always necessary to perform trials for plants in the specific facility.

Trial Rates:

Trial rates are *ppm* IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets (see pages 14-15 for conversion charts)

Woody Ornamental Plants Propagated by Spray Drip Down™ or Total Immerse Methods

Acer	1000-1500	Rosa, varieties	1000-1500
Cotoneaster	500-750	Rhus	500-750
Diervilla, paniculata	500-750	Spirea, Japonica	500-750
Hydrangea	500-750	Syringa	500-750
Juniperus, horizontalis	1000-1500	Thuja	1500-2000
Physocarpus, opulifolius	1000-1500	Viburnum	1000-1500
		Weigela	1000-1500

Trial Rates: Annual Plants Propagated by Spray Drip Down™ or Total Immerse Methods

Pelargonium geranium		Petunia sp.	150-200
sp. like "Balcon"	50-100	some colors	200-300
zonale	200-300	Osteospermum	150-200
peltatum	300-400	Verbena	200-300
Impatient New Guinea	15-50	Poinsettia	25-100
Fuchsia	15-50		



Trial Rates: Perennial Plants Propagated by Spray Drip Down™ or Total Immerse Methods

Trial rates are ppm IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets (see pages 14-15 for conversion charts)

Abutilon	750	Erodium		Origanum	500-750
Achillea	up to 1000	Dark Eyes	750	Paxistima	1000
Actinidia Arctic Beauty		Erysimum	750	Penstemon	500
	1000	Escallonia Comp	500	Persicaria	up to 1000
Ajuga	up to 1000	Eupatorium	500	Phlox	1000
Amsonia	1500	Euphorbia	1000	Phygelius	750
Anisodonte Tara's Pink		Gaillardia	500	Poinsettia	500-1000
	750	Galium		Polemonium	
Antennaria	up to 750	SweetWoodruff	1500	Bressingham purple	
Anthemis	1000	Geranium	1000		1000
Arabis Variegata	500	Geum Rivale	1000	Prunella Loveli.	750
Arctostaphylos	500	Gypsophila Viette'sDwrf		Rosmarinus	500
Armeria	1000		1000	Rudbeckia	750
Artemisia	up to 500	Hedera	1000	Ruellia	1000
Baptisia	3500	Helenium	500	Salvia	500-1000
Basil Kasar	500	Helianthemum	2000	Santolina	500
Buddleia	1000	Helianthus	1000	Saponaria	1000
Calamintha Var.	500	Helichrysum	500-1000	Saxifraga	750
Callicarpa	500	Heliopsis	1000	Scabiosa	1000
Campanula	500-1000	Hypericum	1000	Silene	500
Caryopteris	1000	Hyssop PinkDel.	500	Solly Boddy'sCh.	750
Ceanothus	500	Iberis	1000	Spilanthes	500
Ceratostigma	1500	Itea Little Henry	1000	Spiraea	1000
Chrysanthemum		Kerria	1000	Spiraea Gold Flame,	
	500-1000	Lamiastrum		Magic Carpet, Neon	
Chrysogonum	750	Herman Pride	1000	Flash	4000
Cistus	750	Lamium	up to 1000	Stachys	1000
Clematis	1000	Lavandula	1000	Stevia	
Clethra	1000	Leptospermum	500	rebaudiana	500
Coleonema	750	Linaria	500	Teucrium	1000
Convolvulus	750	Lithodora	2000	Verbascum	1000
Coreopsis	500-1000	Lonicera	1000	Verbena	750
Correa	500	Lychnis	1000	Vinca	1000
Cosmos	1000	Marjoram		Viola	1500
Cotoneaster		Compactum	500	Vitex	1000
Coral Beauty	500	Melissa	up to 500	Waldsteinia	1000
Delosperma	1000	Mentha	500	Weigela	1000
Erigeron	750-1000	Nepeta	500	Westringia	750
		Oenanthe	500		

Trial Rates for Basal Quick Dip Method

Make Rooting Solutions using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. Use the trial rate charts as a starting point.

Use on cuttings in the growing season and winter dormant cuttings.

- Immerse basal end of cuttings approximately 1" in Rooting Solution a few seconds.
- Stick immediately or store.

Trial rates are *ppm* IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets (see pages 14-15 for conversion charts)

CUTTING TYPES	Hortus IBA Water Soluble Salts (<i>ppm</i> IBA)
Annuals, soft perennial, tender cuttings from ornamental plants, tropical house plants	50-200
Herbaceous, perennials, pot rose cuttings	150-1500
Difficult to root herbaceous, perennials, tropical house plant cuttings	500-1500
Softwood cuttings	500-1500
Hardwood cuttings	500-2000
Difficult to root hardwood cuttings SEE THE NOTE BELOW	2000-10,000

Some cuttings are hard-to-root. This may be caused by the condition of the cuttings, the maturity of the cuttings, or the timing when cuttings are taken. Some growers *'think'* the answer is to use a high rooting hormones rate. They usually get *in-consistent rooting or no roots at all.*

A better answer is to use the Basal Long Soak Method. Even though low rates are used, the cuttings have more Rooting Hormone stored at the basal end so that rooting is successful.

Trial Rates for Basal Long Soak Method

Make Rooting Solutions using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. Use the trial rate charts as a starting point.

Use on cuttings in the growing season and winter dormant cuttings.

- Immerse basal end of cuttings approximately 1" in Rooting Solution for 12 to 48 hours.
- Stick immediately or store.

Trial rates are ppm IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets (see pages 14-15 for conversion charts)

CUTTING TYPES	Hortus IBA Water Soluble Salts (ppm IBA)
Hard to root annuals and perennials	25-100
Herbaceous cuttings	50-200
Woody ornamental cuttings, grape, roses	50-400

Typical annual, perennial and other herbaceous plants

Aeonium	Dahlia	Heliotropism
Araucaria	Delphinium	Hydrangea
(Norfolk Island pine)	Dracaena	Phaseolus
Aster	Dipladenia	Pittosporum
Azalea	Gypsophila (baby's breath)	Rosa (rose)
Cryptomeria (J. cedar)	Hedera (ivy)	Trachelium (throatwort)
Cupressus (cypress)		

Typical hardwood and softwood, difficult to root cuttings

Apple (malus) rootstock	Elaeagnus	Ribes (currant)
Aralia	Ficus (fig)	Robinia (false aralia)
Barberry	Forsythia	Salix (willow)
Callicarpa	Halesia (silverbell)	Redwood, coastal
Calocedrus	Holodiscus	Taxus (yew)
Carpinus (hornbeam)	Juniper	Thea (tea)
Cephalotaxus (J. plum yew)	Metasequoia (sequoia)	Theobroma (cacao)
Centaurea (knapweed)	Nerium (oleander)	Thuja
Chaenomeles	Olive	Thujopsis
(J. flowering quince)	Philadelphus (mock orange)	Torreya
Citrus	Physocarpus (ninebark)	Tsuga (hemlock)
Corylus (hazel)	Picea (spruce)	Ulmus (elm)
Cryptomeria (J. cedar)	Populus (poplar)	Viburnum
Cupressocyparis	Potentilla (cinefoil)	Vitis (grape)
(Leyland Cypress)	Prunus (peach rootstocks)	Weigela
Cytisus (broom)	Pseudotsuga (Douglas fir)	Wisteria
Derris (rubber)	Rhododendron	

Trial Rates for Dry Dip Method



Rhizopon® AA #1

Active ingredient 0.1% IBA

Pink Color Powder

Use on easy to root cuttings.

Rhizopon® AA #2

Active ingredient 0.3% IBA

Green Color Powder

An intermediate all purpose product.

Use on easy to more difficult to root cuttings

Rhizopon® AA #3

Active ingredient 0.8% IBA

White Color Powder

Use on more difficult to root cuttings

Rhizopon AA #1, #2 and #3 Dry Dip Rooting Hormones are not used to make Rooting Solutions.

SELECT THE RHIZOPON AA ROOTING POWDER FOR MANY TYPES OF PLANT CUTTINGS

SEASON	CUTTING TYPE	Rhizopon AA Dry Powder
In the growing season	Leafy cuttings: annuals	#1 or #2
	Leafy cuttings: perennials	#1, #2, or #3
	Leafy cuttings: woody ornamental and forestry	#2 or #3
All year	Tropical plants	#1 or #2
	Annuals	#1 or #2
	Perennials	#1, #2, or #3
	Woody ornamental and forestry plants	#2 or #3
Winter dormant cuttings	Woody ornamental and forestry plants	#2 or #3
All year	Hard to root cuttings	#2 or #3

Trial Rates for plants propagated by the Dry Dip Method using Rhizopon AA #1, #2 and #3

After the plant name is the product number for Rhizopon AA #1, #2 and #3 Dry Dip rooting hormones.

Various rates may be used for species dependent upon the variety, time of the year, condition of the stock plants, facility, environmental factors, and other variables.

Rhizopon AA #1, #2 and #3 Dry Dip Rooting Hormones are not used to make Rooting Solutions.

Abelia	#1	Chokeberry	#2 or #3	Franklinia	#2
Acanthopanax	#3	Chrysanthemum	#2	Fringe Tree	#2
African Violet	#1	Cinquefoil	#2	Fuchsia	#1
Ageratum	#1	Clematis	#2 or #3	Gardenia #1, #2 or #3	
Andromeda	#1	Clerodendron	#1	Geranium	#1
Apple, Malus	#2 or #3	Clockvine	#1	Germander	#2 or #3
Arborvitae	#2 or #3	Coleus	#1	Ginkgo	#2
Arbutus	#3	Cotoneaster	#3	Golden Chain	#2
Ardisia	#2	Crab Apple	#2 or #3	Grape	#3
Azalea var		Cape Myrtle	#1	Hawthorn	#3
	#1, #2 or #3	Crassula	#1	Hazelnut	#1 or #2
Barberry	#1	Creeper	#1	Heath	#3
Bayberry	#1	Croton	#1	Heather	#3
Beauty Bush	#3	Cryptomeria	#3	Hemlock	#2 or #3
Beauty Berry	#1	Currant	#1	Hibiscus	#2 or #3
Beech	#2	Dahlia	#2	Holly, Japanese	#2
Begonia	#1	Daphne	#1 or #2	Holly, American	#3
Birch	#3	Deutzia	#1	Honeysuckle	#2
Bittersweet	#3	Dew Berry	#1	Hydrangea	#2
Blackberry	#1	Dogwood	#3	Jetbead	#1
Bluebeard	#1	Douglas Fir	#3	Juniper var.	#2 or #3
Blueberry	#1 or #2	Dove Tree	#1	Kerria	#1
Bougainvillea	#3	Dracaena	#1	Knotwood	#3
Boxwood	#3	Dutchman's Pipe	#1	Laburnocytisus	
Broom	#1 or #2	Elder	#1 or #2		#1 or #2
Butterfly Bush	#1	Escallonia	#2	Lantana	#1
Camellia	#3	False Arborvitae	#2	Laurel	#3
Candytuft	#1	Firethorne	#1 or #2	Lavender	#2
Carnation	#3	Flowering Cherry	#1	Leucothoe	#2
Catalpa	#3	Flowering Quince	#3	Lilac	#3
Chaste Tree	#3	Fontanesia	#1	Lily Scales	#1 or #2
Chestnut	#3	Forsythia	#1	Linden	#1

Locust	#3	Periwinkle	#2	Spiraea	#1
Magnolia	#2 or #3	Petunia	#2 or #3	Springscent	#2
Manzanita	#3	Philodendron	#1	Spruce var.	#2
Maple, Japanese	#3	Phlox	#1	St. Johnswort	#1
Matrimony Vine	#3	Photinia	#3	Stevia	#1
Melastoma	#1	Pine var.	#2 or #3	Stewartia	#1
Mock Orange	#1	Poinsettia	#1	Sweet Leaf	#1
Mulberry	#1	Poplar	#1	Trumpet Creeper	#1
Ninebark	#3	Prickly Pear Cactus	#1	Tulip Tree	#3
Norway Spruce	#1	Privet	#3	Umbrella Pine	#3
Oak	#3	Raspberry	#1	Verbena	#1
Oleander	#2	Retinospora	#3	Viburnum	#1
Olive	#3	Rhododendron var.	#3	Waxmyrtle	#1
Orange, sour	#3	Rose	#1, #2 or #3	Weigela	#1
Orixa	#1	Russian Olive	#3	Willow	#1
Osage Orange	#1	Sage	#1	Wintergreen	#2
Osmanthus	#2	Sequoia	#2	Wisteria	#2
Pachysandra	#2 or #3	Snapdragon	#1	Witch Hazel	#2
Pea Shrub	#1	Snow Berry	#1	Yellow Wood	#2
Pear rootstocks	#3	Sourwood	#3	Yew var.	#3
Pecan	#3	Speedwell	#1	Zelkova	#2
Penstemon	#1				



Trial Rates using Rhizopon AA Water Soluble Tablets

To make Rooting Solutions using Rhizopon AA Water Soluble Tablets simply count the tablets and mix in water.

- Mix into ordinary water.
- Rhizopon AA Water Soluble Tablets are useful when a scale is not available to measure, and to mix small amounts of Rooting Solution.
- Use the Rooting Solutions by the foliar and basal methods shown in this book.

TRIAL RATES using Rhizopon AA Water Soluble Tablets.

(To use Hortus IBA Water Soluble Salts see pages 14-15 for conversion charts)

Spray Drip Down & Total Immerse Methods	Tablets/liter
Annual, perennial, chrysanthemum cuttings	1-5
Herbaceous and hard to root perennial plant cuttings	5-30
Woody ornamental cuttings	6-30

Basal Quick Dip Method	Tablets/liter
Annuals, soft perennial, tender cuttings from ornamental plants, tropical house plants	1-4
Herbaceous, perennials, pot rose cuttings	3-20
Difficult to root herbaceous, perennials, tropical house plant cuttings	10-30
Softwood cuttings	5-20
Hardwood cuttings	10-30
Difficult to root hardwood cuttings (or use Hortus IBA Water Soluble Salts at higher rates)	30

Basal Long Soak Method	Tablets/liter
Annual and perennial cuttings	1/2-2
Herbaceous cuttings	1-4
Woody ornamental cuttings, grape, roses	1-6

Selecting the Cuttings



Ivy stock plants in Holland

SELECT THE BEST POSSIBLE STOCK PLANTS

The best stock plants produce the best cuttings used for propagation. During each growing cycle, growers must select plants that exhibit the best growth characteristics; these are selected as 'stock plants'. 'Off-shore' cuttings are from selected and maintained stock plants. The same selection process can be done at one's own growing facility.

JUVENILE CUTTINGS

Cuttings taken from the newer *juvenile* parts of many plants root better than older *mature* parts. Shoots at the tops of the plant are physiologically older (*more mature*) than the shoots at the bottom of the plant (*more juvenile*). The top shoots have the characteristics of the more mature parts of the plant from which they originate. **Juvenile cuttings require lower plant rooting hormone rates compared to the 'older' cuttings.**

To maintain juvenality, annual and perennial cuttings should be taken from young stock plants. These stock plants, often a half year old, are used to produce the next generation stock plants from current cuttings. For woody plants 'hedging' can be done.

THE 'BEST' TIME TO TAKE CUTTINGS

Some plants, especially those which go dormant, have different rooting ability at different times of the year. Timing of a few weeks in taking of cuttings may have success or failure. After maturing to a certain age, often years, cuttings taken from certain plants may not be able to produce roots.

TYPICAL TIMING TO TAKE CUTTINGS

- **Herbaceous cuttings from greenhouse crops, annual and tropical plants: anytime.**
- **Deciduous and evergreen plant cuttings: early summer through early fall.**
- **Dormant hardwood cuttings: fall or winter.**

PREPARATION AND CARE OF CUTTINGS

Before taking cuttings, stock plants must be provided with good light and fertilization. This will boost stored carbohydrates used to feed the newly formed roots.

- **Herbaceous** plant cuttings should be treated and stuck soon after being taken. To prevent heat damage, in hot climates cuttings are put in coolers soon after being cut. Perennial and annual cutting suppliers may have offshore stock plant nurseries. When shipped, cuttings from these nurseries are kept chilled during transit using special cartons that protect the cuttings from temperature variation. The cuttings are packed in plastic bags to assure continued hydration. Shipping time is kept short, assuring prompt arrival at the rooting facility. Certain plants do not ship well; to assure propagation success, those stock plants should be grown near the rooting facility.
- Winter **woody cuttings** taken in the fall can be treated with rooting hormones, kept in plastic, stored in cold storage, then planted-out in the spring.
- Growers usually take plant shoot cuttings from plant growth of the current growing season. Generally, thin cuttings will root more easily than thick cuttings. No one cutting type is useful to propagate all plants.

TYPES OF CUTTINGS

STEM CUTTINGS

'Stem cuttings' are the out-growing stems, mature sprouts or tip cuttings. Growers may take many types of stem cuttings.

- **SOFTWOOD & HERBACEOUS CUTTINGS:** these are the fast growing soft tips of stems, usually taken in the spring. Herbaceous cuttings, sometimes called 'tip cuttings' or 'shoot cuttings', are taken from the young soft tips of stems.

Softwood and Herbaceous cuttings have many variations. Cuttings taken from annuals, herbaceous perennials, tropical plants and house plants are easier to propagate from cuttings than more hardened cuttings.

- **HARDWOOD CUTTINGS:** these are taken from the fully mature stems of deciduous shrubs and trees. Stock plants for these cuttings require careful selection and preparation before growers take the cuttings. Pruning of the stock plants allow them to produce new growth early in the growing season. The new growth can produce roots. Growers take these cuttings at the end of the growing season or during the dormant season.
- **GREENWOOD CUTTINGS:** these are the soft tips or stems after the spring growth has slowed. The stem is harder and woodier than the soft wood cutting.
- **SEMI-RIPE CUTTINGS:** these are taken during the late summer after the annual growth has slowed. The stem is harder than softwood or green wood cuttings.

SCION CUTTINGS

'Scion cuttings' are dormant 'ligneous' woody twigs.

EYE CUTTINGS

'Eye cuttings' are pieces of foliated or defoliated stalks with one or more eyes.

ROOT CUTTINGS

'Root cuttings' are parts of the root, usually annual. Growers take these from certain plants which have the capacity to regenerate stems from root parts.

LEAF CUTTINGS

'Leaf cuttings' are parts of the leaf. New roots develop at the base or veins of the cutting. Dry powder rooting hormones are usually used to treat these cuttings.

CUTTING NODES and DO NOT CUT LEAF TIPS

See the section in this book (article after numbered pages):

"Propagate Plants from Cuttings Using Foliar Applied Aqueous IBA Rooting Solutions. Tips: Do's and Don'ts",

Topic: "The Cuttings"

Handling Un-rooted Cuttings

- After taking cuttings, stick as soon as possible.
- **USE PLANT ROOTING HORMONES.**
- Do inspection.
- Reduce wilting during rooting.
- Maintain the appropriate environmental controls.
- Practice good sanitation.

HANDLING OFF-SHORE UN-ROOTED CUTTINGS

After receiving cuttings from off-shore sources, open all boxes immediately. Inspect the un-rooted cuttings for damage, dehydration, heat or freeze damage, breakage or rot. Report any missing items or damaged cuttings to the vendor. Do not allow the boxes to remain in sunny or hot places, or below freezing temperatures. Growers should stick the un-rooted cuttings into pre-moistened, well drained, soil-less media with 5.5- 6.5 *pH*. If it not possible to stick the un-rooted cuttings immediately they can be held for several days in a cooler between 35-45°F. The cuttings will deteriorate rapidly at warm temperatures.

WOUNDING

- Hardwood cuttings may root better if a 1/2 to 3/4 inch long notch, “wound,” is made at the basal end before applying the plant rooting hormone.
- Tropical and other herbaceous cuttings are not 'wounded'.

MEDIA

Stick cuttings as soon as possible after either taking cuttings or receiving off-shore cuttings. Use pre-moistened, well drained, soil-less media with 5.5- 6.5 *pH*. ‘Airy’ media allows oxygen to stimulate root growth. (See page 45 for notes.)

STICKING DEPTH

Stick the cuttings just deep enough that the medium anchors them. Thin cutting may be stuck 1/4-1/2 inch deep.

TRAY SIZE AND DIRECT STICKING

Tray sizes range from 36 to 128 cell. Larger cells are used for cuttings scheduled to remain in the starting tray longer. Un-rooted cuttings can also direct stick in the finishing container or sometimes beds.

Rooting Solutions, Rooting Powders and Methods

Hortus IBA Water Soluble Salts & Rhizopon AA rooting hormones are applied to cuttings from 'easy-to-root' to 'difficult-to-root'. Treated cuttings quickly form new uniform roots, strong root mass and homogenous propagation crops.

SOLUTION METHODS & CUTTING TYPES	Hortus IBA Water Soluble Salts (ppm IBA)
TOTAL IMMERSE & SPRAY DRIP DOWN METHODS Annual, perennials, chrysanthemum Herbaceous and hard to root perennial plant cuttings Woody ornamental cuttings	Trial rates 50-250 250-1500 300-1500
BASAL QUICK DIP METHOD Annuals, soft perennial, tender cuttings from ornamental plants, tropical house plants Herbaceous, perennials, pot rose cuttings Difficult to root herbaceous, perennials, tropical house plants Softwood cuttings Hardwood cuttings Difficult to root hardwood cuttings	Trial rates 50-200 150-1500 500-1500 500-1500 500-2000 2000-10,000
BASAL LONG SOAK METHOD Hard to root annuals and perennials Herbaceous cuttings Woody ornamental cuttings, grape, roses	Trial rates 25-100 50-200 50-400
DRY DIP METHOD & CUTTING TYPES	Rhizopon AA #1, #2, #3
In the Growing Season Leafy cuttings: annuals Leafy cuttings: perennials Leafy cuttings: woody ornamental and forestry All Year Tropical plants Annuals Perennials Woody ornamental and forestry plants, hard to root cuttings Winter dormant cuttings	Trial rates #1 or #2 #1, #2, or #3 #2 or #3 #1 or #2 #1 or #2 #1, #2, or #3 #2 or #3 #2 or #3

Control of the Growing Area

Raising selected stock plants under controlled conditions is important. When growers give their stock plants proper care, the plants will produce the best cuttings. 'Just taking' cuttings from random 'field plants' leads to marginal results. The same way, control of the propagation house is equally important to the propagation of new plants.

Before production, always perform trials on selected plants, within the same facility.



Inspection of cuttings

INSPECTION

Growers must inspect their crops regularly to observe both intended and undesired results. Records should be kept that include information of the methods, materials, and plants used, and the quality of stock plants and cuttings.

ROOTED CUTTING CARE

Early stage treatment of the cutting crop is essential to produce high quality finished plants. Do not allow the rooted cuttings to become over-rooted, dried-out, crowded or under-fertilized. These situations may reduce plant growth.

PROVIDING THE BEST POSSIBLE CONDITIONS FOR ROOTING

Cuttings given less than optimal rooting conditions will waste energy. The result will be inferior root systems. To produce its own store of carbohydrates a plant needs the raw materials of light, water, carbon dioxide and oxygen.

LIGHT

Growers should regulate the propagation house so that the cuttings are not under direct sunlight. The effect of direct sunlight and the resultant heat will cause stress to the cuttings. Light is necessary for photosynthesis. Un-rooted cuttings are not able to engage in much photosynthesis; a small amount of light, 100-125 μm PAR light, during the rooting process is sufficient. It is important at this stage is to provide a long period of light. A

photo-period of 16-18 hours is adequate. Artificial lights are useful to extend natural daylight hours. Natural lighting or artificial lights may cause a rise in ambient temperature. Growers must control the growing area to avoid high temperatures from light sources.

WATER CONTENT OF THE MEDIA

A plant must have a good root system in order for it to absorb water. Water is crucial while the cuttings begin to form roots. If the substrate that is too dry, the plant will have cell death. Dead cells increase the risk of rot. A very dry substrate encourages callus formation. Although many believe that callus is beneficial for root formation, this is not true. The callus hinders and slows root formation. Growers measure how much moisture in the soil with a tensiometer. For best rooting, the meter should display a reading between moist and wet. Another way is to weigh the trays regularly. By trial, the growers determine if the trays have the proper weight for the “the proper moisture level,” then provide water based on these observations.

CARBON DIOXIDE (CO²) IN AIR & OXYGEN IN MEDIA



Environmentally controlled chrysanthemum propagation house in Holland

Photosynthesis is important for cuttings. Photosynthesis requires sufficient **carbon dioxide** (CO²), light, and water. An advantage of an increased level of CO² in the air is that it reduces the transpiration, loss of water, through the plant. Cuttings in an environment with sufficient light and an increased CO² level (800-1000 *ppm*) will form better roots. CO² can be controlled using special generators. **Oxygen** is necessary for cell division and crucial for root formation. Growers

must stick the cuttings into a substrate that has a structure which is sufficiently open to allow air, containing oxygen, to reach the developing roots. Dense media inhibits oxygen stimulation.

AIR CIRCULATION & TEMPERATURE CONTROL

Good air circulation is necessary when rooting un-rooted cuttings. Shade to approximately 50% light conditions, or as required, to reduce temperature during high heat periods.

TEMPERATURE

Soil Temperature

Soil temperature has a direct influence on the speed of rooting. A soil temperature ranging between 68-77°F is ideal during the initial rooting stage. After this initial stage, growers can allow the temperature to drop a few degrees.

Air Temperature

To prevent excess transpiration, controlling the temperature is important. To reduce aerial growth, air temperature should be a bit lower than soil temperature. The cuttings should be encouraged to use their energy mainly for developing roots. Above ground growth will come later.

Light and Temperature Relationship

During the winter, when there is a low level of natural light, with no artificial lights, use a lower temperature. For example, cuttings will die if kept at temperatures near 74°F, short day and low light levels. Rooting activity in the soil will outpace its ability to do photosynthesis induced by the light.

FERTILIZATION

Follow fertilizer label instructions. Growers should fertilize un-rooted cuttings during propagation. Apply a complete N-P-K fertilizer. For many plants, use a fertilizer containing 300 *ppm* of nitrogen approximately two to three times a week. Start on the third day after sticking or when the callus is starting to form. Quality can suffer if the roots become rootbound. Fertilize the cuttings when planting. Apply liquid fertilizer solutions at a rate of 300 to 400 *ppm* immediately after planting.

INSECT AND DISEASE CONTROL

Good cultural practices and clean, well-ventilated growing space are your best defense against disease. Botrytis, the chief fungal threat, thrives in a moist, stagnant environment. Good air circulation and adequate light will reduce its harmful effects.

Apply appropriate fungicides, insecticides, and other control products following label instructions.

Humidity



Un-rooted cuttings must receive the highest amount of humidity. Temperature influences the ambient humidity. When the first roots appear, the humidity can be lowered; the rooted cuttings can adapt to the surroundings better.

MISTING GUIDELINES

Apply mist immediately and frequently to maintain turgidity and minimize wilting while roots develop. Extended days of high humidity may cause some plant cuttings to form aerial roots.

Typical mist cycle for fast to root annual and perennial cuttings	
1-3 DAYS AFTER STICKING	<ul style="list-style-type: none"> • Mist during daylight hours in all stages and the night for the first 3-4 days helps keep the cuttings turgid for optimum rooting. • Mist 10 seconds every 5-10 minutes.
4-7 DAYS AFTER STICKING	<ul style="list-style-type: none"> • Callus is being formed. • Mist 10 seconds every 20 minutes.
8-15 DAYS AFTER STICKING	<ul style="list-style-type: none"> • Roots are being formed. • Mist 10 seconds every 30 minutes. • Depending upon the plant variety, under ideal conditions, mist can be off 10 days after sticking.
AFTER 14 DAYS	<ul style="list-style-type: none"> • Fast to root cuttings can be ready to plant.



The Dutch growing system in this photo has controlled humidity by covering the propagation trays with either transparent or translucent plastic. Edges of the trays are sealed so that no air current at the sides affect the cuttings. No misting system is used.

Articles

Foliar methods: Do's and Don'ts

Propagate plants from cuttings using foliar applied aqueous IBA rooting solutions.

Foliar methods: historical background

Foliar applied rooting solutions for plant propagation from cuttings: historical background and utility

History and methods to apply rooting solutions by basal and foliar methods

by Joel Kroin, Hortus USA Corp.

Physiology of foliar methods and their relationship to the juvenility & maturity of cuttings

Growth regulator effects on adventitious root formation in leaf bud cuttings of juvenile and mature *Ficus pumila*

by F. T. Davies, Jr. and J. N. Joiner

How foliar methods were adopted by Bailey Nursery

Auxin application via foliar sprays

How Bailey Nurseries developed their program to foliar apply rooting solutions when propagating plants from cuttings

by Samuel Drahn, Bailey Nurseries

Label

Hortus IBA Water Soluble Salts

Propagate plants from cuttings using aqueous IBA rooting solutions by foliar and basal methods:

Basal	QUICK DIP
	LONG SOAK
Foliar	SPRAY DRIP DOWN
	TOTAL IMMERSE

Propagate plants from cuttings using foliar applied aqueous (*water based*) IBA Rooting Solutions. Tips: do's and don'ts

Today growers worldwide successfully propagate plants from cuttings using foliar applied aqueous (*water based*) IBA rooting solutions. They use the Spray Drip Down and Total Immerse Methods. Leafy cuttings are taken from annual, perennial, and woody plants in the growing season. Compared with other propagation methods, foliar application has significant labor and material cost savings. Cuttings are treated in bulk at low rates.

Basal methods are still very important when propagating plants from cuttings. Quick Dip especially, has a long successful use and should be considered along side foliar methods as appropriate for needs.

Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablet IBA Rooting Solutions are used for all basal and foliar methods.

A Brief History of Foliar Applied IBA Rooting Solutions

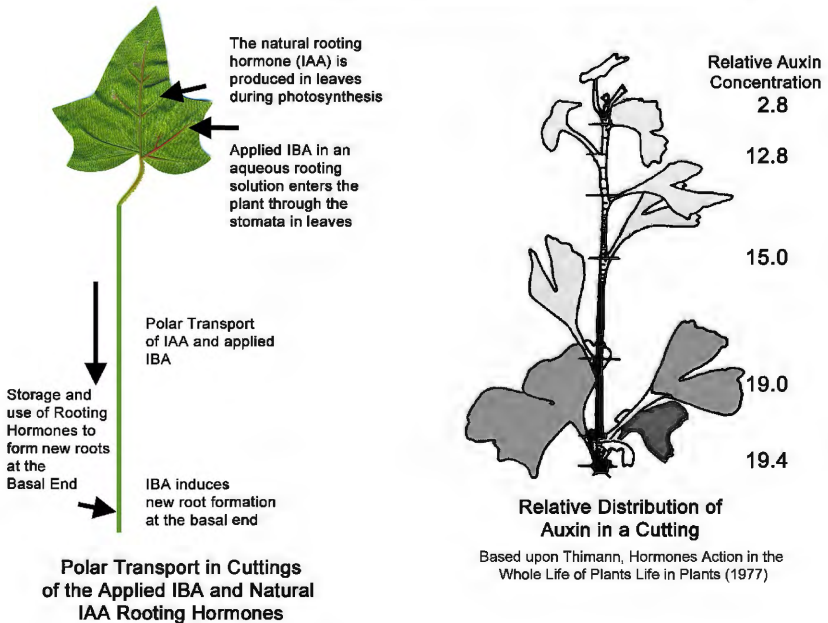
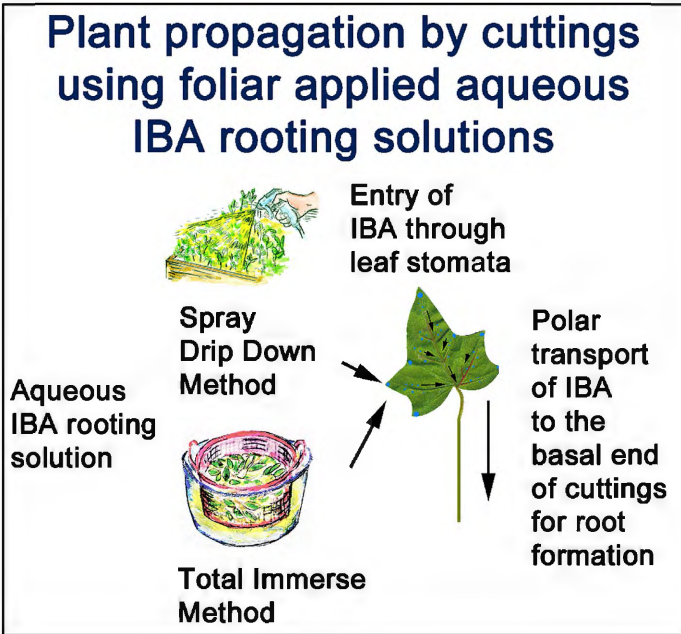
More than twenty-five years ago growers who wanted to propagate plants from cuttings by using rooting hormones were limited to basal application. Scientists had known plants produce growth substances (rooting hormones) in leaves. Charles Darwin, in his book 'The Power of Movement in Plants' (1880), described his study of the production and flow of these substances from the leaves to the lower portions of the plant. Scientists later identified the substances produced by plants. Commercial rooting hormones became available. As scientists and growers advanced procedures to propagate plants from cuttings they only focused on basal application of rooting hormones. They did not consider that foliar application of rooting hormones would naturally translocate to the basal end of cuttings where it can induce root formation.

Dr. Frederick Davies did histological and physiological studies on the foliar application of aqueous IBA rooting solutions (1978). IBA is a well used root promoting substance. The studies were concurrent with his propagation work comparing root formation in juvenile and mature cuttings.

In 1985 Kees Eigenraam, the technical advisor at Rhizopon, introduced to Dutch growers the foliar application of IBA rooting solutions to propagate plants from cuttings. At the time, Kees did not know the research by Dr. Davies. Kees and Joel Kroin began to formalize the foliar techniques later named **the Spray Drip Down** and **Total Immerse Methods**. By the early 1990's they introduced these techniques to US growers. Initially growers of **annual plants** adopted

the methods. Soon after, growers at Yoder (now Aris) Green Leaf Plants and Keepsake Plants began using the Spray Drip Down Method on their many **perennial plant** varieties. They also developed a foliar program on their Yoder brand chrysanthemums.

After 2000, Sam Drahn's studies at Bailey Nurseries led to their extensive use of the Spray Drip Down Method on **woody ornamental plant** cuttings.



Methods to Propagate Plants from Cuttings

Currently five methods are used to propagate plants from cuttings. No one method is best for all plant varieties under all situations. Use the optimum foliar and or basal methods as needed for the plants and operation of the facility.

Basal Methods

Three methods are used to apply rooting hormones to the basal end of cuttings. The methods are used all year depending upon the condition of the cuttings.

Using dry powder rooting hormones ready for use:

- **Basal Dry Dip Method**

Using rooting solutions:

- **Basal Quick Dip Method**
- **Basal Long Soak Method**

Foliar Methods

Two methods are used to apply rooting solutions to the leaves of cuttings. The methods are used on leafy cuttings taken from during the growing season. They are not used on leafless or dormant cuttings.

Using aqueous (water based) IBA rooting solutions:

- **Spray Drip Down Method**
- **Total Immerse Method**

How Does Foliar Application Work?

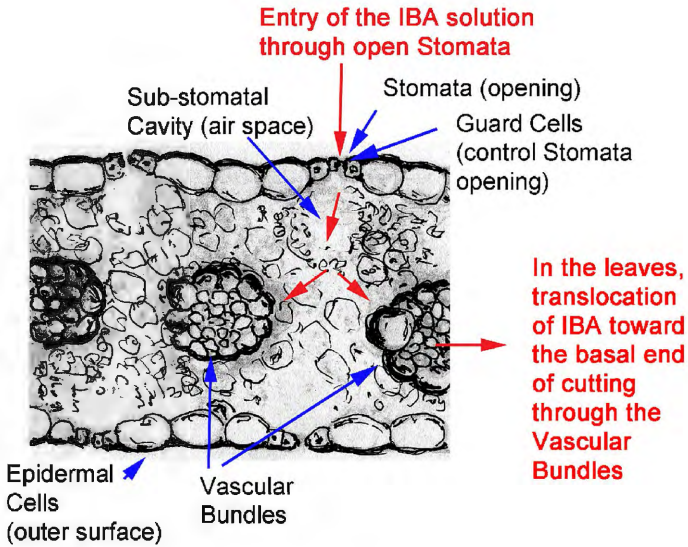
- Leafy cuttings are taken from stock plants in the growing season. Leafless or dormant cuttings are not used.
- The leaves of plant cuttings are treated with aqueous (water based) IBA solutions. IBA can enter the vascular system through open pores in the stomata. Stomata are open in a temperature range from about 60-90°F (15-33°C) and when cuttings are well hydrated before treatment.
- The IBA translocates through the plant's vascular system, by polar (one way) transport, to the basal end of the cuttings.
- At the basal end the IBA induces root formation.

We can look at the IBA flow like a "Ferryboat Carrier Model", a traditional model of biological transport:

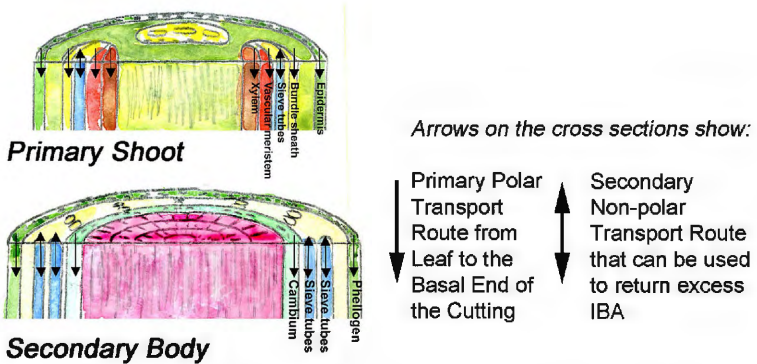
Ferryboats pickup an ever increasing number of passengers on the departure side. They are transported across the river to a small arrival loading dock. The loading dock fills to capacity, then, some passengers are thrown into the river.

A large amount of IBA is applied to the leaves where it enters the plant's system. IBA is polar transported through in the phloem to the basal end where it accumulates. The needed amount of IBA at the basal end initiates new roots. Excess IBA is returned, in the non-polar route, to

the leaves. Returned IBA may cause tender leaves to show some deformities. When return flow stops, new leaves will form normally. Quality roots will form as expected.



Leaf Cross Section: Entry of IBA through open Stomata and Translocation toward the Basal End



Free IBA Transport from Leaves to the Basal End of cuttings through the Primary Shoots and Secondary Bodies

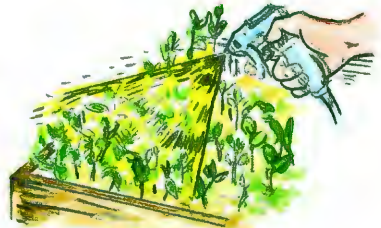
Foliar Methods

Foliar methods are simple.

- Apply aqueous (water based) IBA rooting solutions to leafy cuttings taken in the growing season.
- Labor saving: cuttings are processed in bulk.
- Low rates: low material cost.

Spray Drip Down™ Method

- Stick the cuttings into media.
- Use the selected sprayer.
- **Spray the solution onto the leaves of the cuttings until there is a drip down.**
- Excess application is best.
- The solution gets sucked by capillary action into the plant's subsystem. Wait about 3/4 hour or until the solution dries on the leaves, then turn on misters.



Some benefits:

- No PPE is required for sticking untreated cuttings.
- The Spray Drip Down Method can be used on many small production lots at one time.
- The solutions are used one time. There can be no cross contamination between production lots due to biological matter being dragged into the solution.



Spray until you see
Drip Down of the solution

Total Immerse Method

- Use a tub and strainer basket.
- **Dip the cuttings in the solution until the leaves are completely covered with liquid, about five seconds.**
- Drain.
- Stick the cuttings into media.



Some benefits:

- Simple equipment is used.
- The Total Immerse Method can be used for large homogeneous plant lots that are clean and free of diseases.
- The method requires little setup. It can be used on small lots.
- Can be used to treat large leaves that may be difficult to spray uniformly.

Rooting Solutions for Foliar Methods

Foliar methods use aqueous (water based) IBA solutions.

- Water is the natural fluid in plants that is used to translocate natural rooting substances.

The US EPA requires registration of IBA rooting products. There are only two registered products used to make water-based IBA rooting solutions and labeled for foliar application. These products are:

Hortus IBA Water Soluble Salts

- WEIGH THE SALTS
- Mix into water



Rhizopon AA Water Soluble Tablets

- COUNT TABLETS
- Mix into water



Only Use Water Based IBA Solutions

Do NOT use alcohol base IBA rooting solutions when using foliar application. Alcohol dehydrates plant tissue and causes cutting fatality called 'Alcohol burns'.

Dry powder rooting hormone products, like Rhizopon AA #1, #2 and #3, are not used by foliar application. These products are **INSOLUBLE** in water.

Make Concentrate Rooting Solutions

It is sometimes easier to measure and mix solutions rather than dry measure the Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets for many production tanks. In those cases make up a solution concentrate at the required number of grams or tablets, then, decant the solution into the production tank. Add water to bring the tank to the required volume. Warm water helps to dissolve the Salts and Tablets.

Foliar Rates

- **Annual Cuttings**

Annual cuttings require low rates. Some tender plant varieties and juvenile cuttings are treated at rates 80-100 ppm IBA. If rates are slightly too high there may be some leaf distortion; the roots may form well and new leaves will be normal. Leaf distortion may not be evident on mature cuttings.

- **Perennial and Woody Ornamental Plant Cuttings**

Perennial and woody plant cuttings have a similar range of rates.

The selected trial rates are: 500, 1000, and 1500 ppm IBA

- Rates above 1500 ppm IBA are rarely needed except for some mature cuttings.
- Rates below 500 ppm IBA are sometimes needed for juvenile tender perennial cuttings.

- **Tissue Culture Plantlets**

Use the Total Immerse Method on tissue culture plantlets when transplanting at the third to fifth stages.

- Blueberry example: use two Rhizopon AA Water Soluble Tablets per liter water. Other typical rates are 1-3 Tablets/liter water.

Trial Foliar Application Rates			
using Hortus IBA Water Soluble Salts & Rhizopon AA Water Soluble Tablets			
Cutting Type	Hortus IBA Water Soluble Salts (as ppm IBA)	Initial Trial Rates ▼	Rhizopon AA Water Soluble Tablets (tablets per liter water)
Annuals and tender Perennials	50-250 ppm IBA	125 ppm IBA	1-5 tablet/liter
Perennials	250-1500 ppm IBA	1000 ppm IBA	5-30 tablets/liter
Woody Ornamental	300-1500 ppm IBA		6-30 tablets/liter
TC plantlets at 3rd to 5th stage transplants			1-3 tablets/liter

- Juvenile cuttings require lower rates than mature cuttings.
- **Do not use the same rates for foliar application as used by the Basal Quick Dip Method, they are usually too high.**

Use the Proper Equipment

Spray Drip Down™ Method

Use appropriate equipment for the job for labor saving and effectiveness.

Typical sprayers: hand back pack, hydraulic, site specific sprayer, and automated robots.



Typical Backpack Sprayer

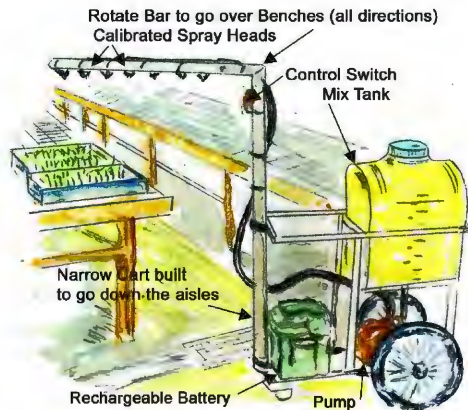


Hydraulic Sprayer
Spray Drip Down Method
(Bailey Nurseries)



Robotic Sprayer
Spray Drip Down Method
on Chrysanthemum (Holland)

This sketch shows a custom spray cart used at Aris Green Leaf Plants in Lancaster PA.



Total Immerse Method

Use a basket for dipping into the solution tank.

- Do not overload the baskets to avoid cutting breakage.
- Do not use a basket or tank made from materials that can corrode.

The top photo shows a large hedera (ivy) greenhouse in the Netherlands. Workers in the back do sticking after Total Immerse treatment in the tank shown.



The bottom photo shows Total Immerse treatment of blueberry Tissue Culture plantlets. Few cuttings are in the basket to prevent damage.



The Cuttings

Cutting Types

- For foliar methods, use leafy cuttings in the growing season; do not take dormant or leafless cuttings. For those cuttings use the basal Dry Dip, Basal Long Soak, or Basal Quick Dip Methods.
- Cutting Maturity
 - Do not use hard woody or old mature cuttings.
 - **Juvenile cuttings** are easier to propagate from cuttings compared to those which are mature. When possible, take cuttings from cuttings. Juvenile cuttings require lower IBA rooting solution rates than mature cuttings.
- Bad cuttings cannot be revived.

FOR ALL PROPAGATION METHODS

Cutting Nodes

- Use cuttings that do not have nodes or buds at the basal end.

Do Not Cut Leaf Tips

In old-school for propagation by other methods, some growers cut the tips of large leaf cuttings to obtain more cuttings in a propagation tray.

There are reasons NOT to cut the tips:

- The cut causes a wound that is open to infection.
- The cuttings have reduced natural rooting substance IAA formed at a usual place, the tips of leaves. The natural IAA works with the applied IBA to induce roots. With the tips cut, there is less IAA available.
- With a wound present, the cuttings use valuable resources to heal, rather than induce root formation.
- Growing compact stock plants allow taking cuttings from an earlier stage where the preferred leaves are smaller.



Not acceptable
bud or node

Acceptable with
no bud or node



Use cuttings without
cutting tips

Importance of the Stomata

Stomata are located on outside surfaces of plants. When stomata pores open they allow fluid, vapor and gas exchanges between the plant and it's environment. Stomata on some plant varieties are more numerous, larger, and on the underside of leaves. In some varieties there are more stomata on the underside.

- Stomata
 - **open** when cuttings are well hydrated.
 - **open** when temperatures and other factors are suitable for translocation of fluids and air.
 - **close** when cuttings are wilted.
 - **close** when protecting the plant from exchanges under harsh environmental conditions.
 - **close** in the dark and open in the light.



Typical winter leaf curl on Rhododendron

Sometimes identifying the primary stomata side is easy. Leaf curl means the plant is under stress leading to closed stomata interior to the curl. *The photo shows leaf curl due to bottom closed stomata, protecting against harsh winter environment.*

Foliar Method considerations:

- The Total Immerse Method gets the IBA solution on both sides of leaves.
- Spray Drip Down Method should be used to spray leaves both top and bottom.
- Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets solutions are made to have free IBA entry into the plant's vascular system.

Coverage by the Spray Drip Down Method

The person doing spraying must see the solution drip down from the leaves. This is a visual indicator that an adequate amount of solution has been applied. The top and bottom of cuttings should be treated.

Foliar Spray Solution Utilization

Using the Spray Drip Down Method, the amount of solution needed to cover an area varies. Typical solution use is about 200 sf/gallon (10 sq meter/liter).

Total Immerse Method Timing

Using the Total Immerse Method dip cuttings in the solution until the leaves are completely covered with liquid, about five seconds.

Foliar Spray Drip Down™ Method for Multiple Applications and Transplanting

When plant cuttings utilize applied rooting solutions and rooting hormone powders, some cuttings apparently need a steady flow of the IBA. If one time application is inadequate, daily **sequential Spray Drip Down Method** solution application induces root cell division during time based cell activity.

Where cuttings are known slow-to-root or have low percentage rooting, sequential Spray Drip Down Method may be an option. Then, where high IBA rates had been used unsuccessfully, lower sequential IBA rates may result in better rooting performance. Using the Spray Drip Down Method on transplants gives an extra boost for root cell regeneration.

The trial rates listed previously in this article use the Spray Drip Down Method using solutions made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets.

Sequential Three Day Treatment

After sticking, many growers increase root formation and root mass when applying the rooting solution by the Spray Drip Down Method, in a three day sequence, at the same initial rate.

Leveling Crops

Secondary Spray Drip Down Method foliar applications can be used on leafy cuttings in the active growing state no matter how they were first treated by any rooting method. The second application may help to improve root formation on slow-to-root cuttings. Applications may be done weekly or as required to improve the leveling of crops. Some plant growers use this method on all their production, whether or not the rooting is considered slow. Rates are similar to those used for first foliar application.

Annual cuttings

Trial Range

100-150 ppm IBA

Improving Rooting of 'Slow-to-Root' Cuttings

Secondary Spray Drip Down Method foliar applications can be used on slow to root cuttings in the active growing state using the same initial rate. For cuttings first treated by another rooting method use the Spray Drip Down rate recommendations.

Spray Time of the Day

Sometimes spray is done early the morning following the day of sticking. Where ambient temperatures are high, early morning treatment at cool temperatures has benefit; leaf stomata are open.

Treatment of Transplants and Divisions

When rooted cuttings and plant divisions are transplanted they require stimulation to regenerate and make new root cells. Use the Spray Drip Down Method on planted cuttings and divisions.

	<i>Trial Ranges</i>
Grass divisions & annual rooted cuttings:	100-150 ppm IBA
Perennial rooted cuttings:	750-1000 ppm IBA
Woody ornamental rooted cuttings:	750-1000 ppm IBA

Labor Saving

Growers find foliar methods require less labor than basal methods.

- It is faster to stick cuttings when they are batch treated as compared with individual basal treatment.

Hybrid Propagation Systems and Solution Product Inventory

- Many growers use a hybrid system of both basal and foliar applications in the same facility. By season, foliar methods may be used with some crops, dry powder rooting hormones or basal quick dip for others.
- When using aqueous IBA rooting solutions you can use the same product for both basal and foliar application solution needs. There is no need to stock more than one product.

Foliar Application Temperature

- For foliar methods do not apply when the cuttings and solutions are at low or high ambient temperatures. Use foliar application when the temperature of both the solution and cuttings are at about 60-90°F (15-33°C).

Sticking and Treatment Timing

- Apply by the Spray Drip Down Method within the day of sticking.
- For cuttings kept in a hot climate, such as southern Florida, cuttings are stuck during the day and treated early the following morning.

Cutting Hydration and Misting

Well hydrate cuttings before foliar treatment:

- Hydrate cuttings before treating to assure the stomata are open. This will allow the IBA solution to enter the vascular system.
- Wilted cuttings have closed stomata. The cuttings must be fully hydrated before treatment.

Well hydrate cuttings after foliar treatment:

- When using the Total Immerse Method, misters can be turned on any time after sticking. There is always a lag time between treatment and sticking.
- When using the Spray Drip Down Method, wait to turn on misters about 3/4 hour or until the solution dries on the leaves.
- Some growers of chrysanthemum find they get better rooting when they let the cuttings lose turgor before turning on misters.

Use Appropriate PPE

- Use the most effective PPE that complies with the product label. Unless otherwise specified, thin waterproof gloves are adequate for handling aqueous (water based) IBA rooting solutions.
- No chemicals are handled by sticking personal when using the Spray Drip Down Method, therefore no gloves or other PPE are needed. Thin gloves may be used solely for sanitary purposes.

Rooting Solution Disposal

See page 17 of this book

No Wetting Agents

- Using foliar methods there is no need to use wetting agents in solutions made with Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets.

Overcoming Problems

Trials are Essential

- **Always do trials on small lots before doing production.** Evaluate a range of rates and methods.

Typical Deformities on Tender Plant Cuttings

Leaf curl and spotting are sometimes due to too high an IBA rate, but reversible.

- When IBA is applied to the leaves of cuttings, it is absorbed into the vascular system then translocated to the basal end by polar transport. At the basal end the IBA is accumulated. If there is an IBA excess, it will move back to the leaves causing leaf deformities such curl or spotting.
- Despite initial leaf irregularities, the cuttings will usually form normal roots and normal new leaves.



Leaf Curl



Leaf Spotting

Consider Plant Variations

For any successful method of propagation there sometimes may be unexpected results. “The” method or rate may be considered the culprit even though there was not knowingly change to the rate, method, timing, product, or other factors.

A common problem when using foliar application of rooting solutions is selection of juvenile vs mature cuttings. With excessive rates, juvenile cutting may exhibit distortions in leaves. Juvenile cuttings require lower rates than mature cuttings.

Some of many things to consider:

- Genetic variations of the cuttings: different stock plants.
- Quality of the cuttings.
- Deviations in the growing area such as changes in the environmental control systems and facility.
- Cuttings taken from a different part of the stock area, location, or plantation.
- Timing of taking cuttings from previous.
- Seasonal variations from the norm.

Conclusions

Foliar applied rooting solutions by the Spray Drip Down and Total Immerse Methods are useful for propagating plants from leafy cuttings in the growing season. Opposite to foliar application, there are times when basal applied rooting powders and rooting solutions are more useful.

Consider:

- The plants being propagated.
- The time of the year that propagation is being done.
- The quality of roots produced on the cuttings.
- The facility advantages and setup cost.
- Labor factors including time saved or lost in the process and training.
- Material cost.
- Always do trials on small lots before doing production.
- Evaluate a range of rates and methods.
- Try different methods on a variety of plants when propagating from cuttings. All the methods have proven useful under appropriate conditions: the basal Quick Dip, Basal Long Soak, Dry Dip Methods, and the foliar Spray Drip Down and Total Immerse Methods.
- Consider a hybrid system. To produce an optimum crop it may be beneficial to use several methods concurrently. Basal methods may be used on a crop at one time of the year and foliar methods at another time.

Foliar Applied Rooting Solutions for Plant Propagation from Cuttings: Historical Background and Utility

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INTRODUCTION

The propagation of plants from cuttings using foliar methods is easy:

- Take leafy cuttings in the growing state.
- Apply aqueous (water based) IBA rooting solutions to the leaves by spray or total immerse dip.
- Sticking is done either before or after treatment depending upon the method.
- Roots are produced at the basal end of the cuttings.

Today foliar applied aqueous IBA rooting solutions are successfully used to propagate leafy cuttings taken in the growing state. Fundamentals of the process seem obvious. It had been known for over a century that some substances were produced in leaves, causing plant growth regulation in other parts of the plant. These natural substances, called auxins, have been identified. The basic natural auxin, IAA, was found produced in leaves. Contained in aqueous solutions, auxins can be applied to leaves. These solutions can enter the vascular system of plants through pores in leaves called stomata. Inside the system, the auxins move by polar transport to the basal end of cuttings. Though physiological interactions, scientists believe that IAA becomes another natural auxin, IBA. Therefore, when an IBA in aqueous rooting solution is applied to leaves, it can enter the vascular system. IBA can be transported, with the leaf produced IAA, to the basal end. At the basal end, by processes still unknown by scientists, IAA and IBA induce cell division resulting in root formation.

BACKGROUND

For more than a century, botanists debated how plants regulate growth. One of the mysterious phenomenon, root cells form in apparently normal plant tissue. Julius Sachs (1892) proposed specific substances act to form leaves, roots, or stems, moving with polarly in specific directions. His theory was that the root

forming substance was formed in leaves and translocates to the lower parts of the plant, there stimulating root production.

The later generation scientist, Fritz Went was influenced by Sachs' ideas. Went's doctoral thesis (1928), developed the 'bio-assay' technique. Bio-assay is used to identify substances developed in tips of plants which translocate to lower portions of the plant for growth regulation. Using bio-assay, Went and Kenneth Thimann (1934) identified the plant growth regulator Indole acetic acid, IAA, as a natural substance produced in leaves. IAA has the ability to translocate within the plants' vascular system. Using IAA as a starting point, they identified other close compounds, 'auxins', which potentially have similar plant growth regulator activity.

Of the auxins, Indole butyric acid (IBA) and Naphthalene acetic acid (NAA) were found to have utility in plant growth regulation. Recently, IBA was found naturally occurring. After the discovery that auxins were important for root formation, it was well known, these natural substances were produced in inadequate amounts to initiate root formation on most plant cuttings. For those cuttings that cannot form roots on their own or are slow-to-root, external applications of auxins are required to achieve rooting.

After identification of the auxins, Went, Thimann, the Boyce Thompson Institute researchers, and other scientists, developed techniques to use them. Their research on root formation was limited to basal application, for intended root formation. They locally applied auxin based dry powders (rooting hormone powders), auxin solutions, (rooting solutions), or auxin containing lanolin pastes to the basal end of cuttings. Positive root formation was observed.

Believed to be the first studies, foliar applied auxin solutions were successfully used to root of carnation cuttings by D.W. Cheever (1967). The earliest published histology study on foliar applied aqueous IBA rooting solutions was Frederick Davies' PhD thesis (1978). Cuttings were taken in the growing state. Davies demonstrated root formation on *Ficus pumila* juvenile cuttings require lower IBA rates, with higher root numbers as compared to mature cuttings. (Davies and Joiner's article on their research is in this book.)

After the discovery of auxins, in Holland, the Amsterdam Chinin Factory (ACF) first produced commercial auxins under their Rhizopon division (1940). Rhizopon manufactures commercial plant rooting products, both dry dip powders and water soluble tablets to make rooting solutions. To improve use of the rooting solution products, the Rhizopon scientist Kees Eigenraam developed the first commercial foliar methods (1985). At the time, Eigenraam did not know the research by Davies. The first commercial users were Dutch growers propagating

chrysanthemum cuttings. These growers found, foliar application reduced labor and improved the root formation of cuttings.

Joel Kroin, of Hortus USA, first met Eigenraam in 1989. They discussed the foliar methods that were newly used. Other than Rhizopon's data sheets, Kroin could not find anything written about foliar methods. Literature of the time said plant propagation from cuttings was limited to basal methods. Lacking foliar nomenclature and other basic information, Kroin termed the 'Spray Drip Down Method' and 'Total Immerse Method'. Over the years, Kroin and Eigenraam improved and documented foliar methods.

For use of foliar and basal methods, Hortus USA, introduced US growers to Rhizopon AA Water Soluble Tablets (measured by counting tablets) (1993). Tablets, when dissolved in water, make aqueous (water based) IBA rooting solutions. Among the first US foliar method users were the Yoder chrysanthemum propagators in Florida. Soon after, Yoder established their perennial propagation facility, now called Aris Green Leaf Plants, in Lancaster PA. There they began using the foliar Spray Drip Down Method. Keeping concise records, they established rates for thousands of named plant varieties. Their cuttings are taken from juvenile stock plants, resulting in rooting uniformity. Significant for propagators of high volume annual and perennial plants, foliar methods save labor. Cuttings are treated in bulk rather than individually. Low rooting solution rates result in low material cost. Hortus USA developed Hortus IBA Water Soluble Salts, measured by weighting powder, to meet the aqueous (water based) IBA rooting solution needs of plant propagators.

Soon after, Bailey Nurseries' research director Sam Drahn, started to use the Spray Drip Down Method to root woody ornamental cuttings. Based upon his data, it became apparent, the rates for woody ornamental plant cuttings are similar to those obtained by Dr. Davies' juvenile cuttings, and the perennial cuttings of Green Leaf Plants.

Using this information, rates were established for two basic groups of cutting rates for juvenile leafy cuttings that are in the growing state. Rates for mature leafy cuttings are higher than the rates for juvenile cuttings.

Cuttings of perennial and woody ornamental plants require the same rates; the midpoint trial rate is about 1000 ppm IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. (Drahn's article on his research is in this book.)

Cuttings of annual plants require very low rates; the midpoint trial rate is about 125 ppm IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets.

The technology of foliar application of aqueous (water based) IBA rooting solutions are based upon plant physiology. Water is the

natural fluid carrier in the plant's vascular system. As previously described, it has been found that both IAA and IBA are naturally produced by plants. IAA produced in leaves is usually inadequate for root initiation. IAA is unstable; it decays rapidly due to biological factors, light, and heat. Whereas, IBA is stable when needed for root initiation. Compared with IAA, IBA has greater ability to initiate roots. Various studies suggest IBA may be a very simple 'conjugate' of IAA and must be converted to IAA by β -oxidation. As such, either IAA or IBA may be the substance that induces cell division and root initiation. The plant can use the applied IBA as a booster where natural IAA is not sufficient for root formation. It has also been shown, auxins translocate from the apical to basal portions of the plant section.

The foliar entry point of applied aqueous (water based) IBA rooting solution into the plant is through the structure called 'stomata'. While mostly found on the underside of leaves, stomata can also be found on other plant parts including upper leaf surfaces, stems and specialized structures. Their function is to regulate interchange of gases, including water vapor, between the plant and the environment. The stomata have two principal parts, the internal pore and the surrounding guard cells. Guard cells regulate the size of the pores. For foliar application of rooting solutions to work successfully the pores must be open. Studies show stomata are open when cuttings are well hydrated and when temperatures and other factors allow translocation of gas, vapor and liquid. Stomata close when cuttings are wilted.

Stomatal cavities contain air spaces and leaf mesophyll cells that can absorb fluids such as aqueous (water based) IBA solutions. Rooting solution absorption is caused by pressure differentials between the relative humidity outside the leaf and the stomatal cavity, (for example, VPD 'vapor pressure deficit'). After the applied IBA rooting solution enters the leaves, it is absorbed and enters vascular bundles (the phloem). The bundles facilitate translocation of fluids through the plant. Along with leaf produced IAA, the applied and natural IBA is translocated in a polar direction to the basal end of the cuttings; adventitious roots are initiated and formed. If an excess of IBA is foliar applied, it may be possible for it to return, by non-polar transport, to upper portions of the cutting. If so, herbaceous cuttings may exhibit leaf curls or spotting. If the excess were not too high, the cuttings will still produce proper rooting and growth. Lowest possible IBA rates avoid such phytotoxicity.

METHODS

Three basal and two foliar methods are successfully used to propagate plants from cuttings.

Three basal methods, the Dry Dip, Basal Long Soak and Quick Dip Methods, have been used since discovery of auxins. Cuttings of active growing or dormant annuals, perennials, and woody plants can be used.

The Dry Dip Method uses dry powder rooting hormones. Basal ends of the cuttings are dipped into the powder then stuck. The Basal Long Soak Method, was well used through 1950's. The method uses rooting solutions. Basal ends of the cuttings are soaked into the rooting solution for several hours then stuck. The Quick Dip Method uses rooting solutions. Basal ends of the cuttings are dipped into the rooting solution for a few seconds then stuck.

Two foliar methods, the Spray Drip Down and Total Immerse Methods have been in use as described previously. Cuttings of actively growing or dormant annuals, perennials, and woody plants are used. The methods use aqueous (water based) IBA rooting solutions made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. The Spray Drip Down Method is used on cuttings that are first stuck. The rooting solution is sprayed onto the leaves until liquid drops are seen to drip down. Drop formation on the top and bottom of the leaves is preferred. The Total Immerse Method has cuttings totally immersed in the rooting solution for a few seconds then stuck. Rates for the two Methods are similar.

Compared with basal methods, foliar methods have improved rooting quality, reduced misses, reduced labor cost, and material cost savings. Basal methods can be used on cuttings taken all year. Foliar methods can be used on cuttings taken growing state. Selection of the method to be used for particular cuttings should be based upon facility needs, direct and in direct cost, the plant variety, and growing state. In the same facility, some plant taxa, such as selected cultivars of Chrysanthemums or Roses, are sometimes propagated in parallel using either foliar or basal methods.

ROOTING STATIONS AND LINER PROPAGATORS USE FOLIAR METHODS

The Spray Drip Down Method is used by annual plant growers including Dummen's Red Fox rooting stations and Yoder Chrysanthemums. Some perennial plant grower users are Aris' Green Leaf Plants and Keepsake Plants. Many woody plant growers also use it, including Bailey Nurseries. Total Immerse is extensively used on crops such as many perennials, and other plants such as phlox, dianthus, and heder (ivy). The Total Immerse Method is also used on tissue culture plantlets when transplanting in the greenhouse stage.

FOLIAR METHODS

THE TOTAL IMMERSE METHOD

The Total Immerse Method is used on cuttings taken in the growing state. Small or large homogeneous plant lots can be used. To avoid cross contamination between production lots, cuttings must be clean and disease free. Cuttings are treated then stuck. Rooting Solutions are made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets.

Cuttings are dipped into the rooting solution until the leaves are completely covered with liquid for about five seconds. The result is, leaves have treatment on both their tops and bottoms. After draining, the cuttings are stuck into media. A simple tub and strainer basket are used to treat the cuttings. It is important not to over-load baskets to avoid cutting breakage. Dipped cuttings bring biological materials into the solution. Disposing of the rooting solution between dissimilar cutting lots is best. When homogeneous lots are treated, the rooting solution should be disposed at the end of the production day or period. Personnel Protection Equipment (PPE) is required as stated on the product labels.

THE SPRAY DRIP DOWN™ METHOD

The Spray Drip Down Method can be used on small or large plant lots. Cuttings of different types can be treated together. Cuttings are stuck then treated. Rooting solutions are made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets.

After sticking cuttings, the rooting solution is sprayed onto the leaves until there is a drip down. The drips are visual indicators of the adequate amount of applied solution. Leaf treatment should be both their top and bottom. An excess application is best. After spray treatment, misters can be turned on after about 3/4 hour or until the rooting solution dries on the leaves. Typical application

uses about 10 m²/ liter (190-220 ft²/gallon). Various types of sprayers are used such as backpack, hydraulic, boom, or custom made. The rooting solution is used one time. Since the unused rooting solution is kept in the sprayer tank, there is no possible rooting solution contamination between production lots. No personnel protection equipment (PPE) is required to stick untreated cuttings. Thin gloves may be used solely for sanitary purposes.

SOLUTIONS USED BY FOLIAR METHODS

Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets are US EPA registered. Mixed with ordinary water, they are used to make aqueous (water based) IBA rooting solutions. Their labels approve use by basal and foliar methods. When used by foliar methods, it is not necessary to use of wetting agents with their solutions. Where foliar and basal methods are used in the same facility, it is only necessary to inventory one or both products for any method.

A gram scale is used to weight Hortus IBA Water Soluble Salts or large quantities of Rhizopon AA Water Soluble Tablets. Or, Tablets can be counted. The Salts or Tablets are dissolved in water. If a concentrate is made, it can be added to the production tank; water is added to bring to the required liquid volume. Warm water, at hand washing temperature, makes dissolving easier than when using cold water. For ease of handling, concentrate Hortus IBA Water Soluble Salts aqueous IBA rooting solutions can be made to over 80,000 ppm IBA. Solutions should be made soon before use. Unused rooting solutions can be kept a short period. Solutions that have cuttings dipped-in should be discarded soon after use.

RATES (See page 30-38)

The Spray Drip Down and Total Immerse Methods use similar rates for cuttings. Rates used by the Basal Quick Dip Method are usually too high for foliar methods. Juvenile cuttings require lower rates than mature cuttings. Plants growers generally know which of their cuttings are seasonally easy or hard-to-root and adjust their rates. Where leaf distortions occur, the rates are to be adjusted downward.

Annual and tender plant cuttings, and some juvenile cuttings, selected rates at about 80 to 200 ppm IBA using solutions made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. The midpoint trial rate is about 125 ppm IBA.

Perennial and woody ornamental cuttings require similar rates. Selected rates at about 500, 1000, and 1500 ppm IBA using solutions made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. The midpoint trial rate is about 1000 ppm IBA. Mature cutting rates above 1500 ppm IBA are rarely used. Juvenile and tender cuttings, rates below 500 ppm IBA are used.

RATES: DIVISIONS AND CUTTING TRANSPLANTS.

The Spray Drip Down Method is used to treat divisions and young rooted cutting transplants after transplanting. Cutting transplants require the same rates as if they are unrooted. Ornamental grasses transplant divisions require rates as if they were annual cuttings.

RATES: TC TRANSPLANTS.

When transplanting tissue culture plantlets, the Total Immerse Method is used with Rhizopon AA Water Soluble Tablets at about one to three tablets/liter solution. As a guideline for TC rate selection, the rate for cultivated highbush blueberry TC transplants is about two Rhizopon AA Water Soluble Tablets/liter solutions (One tablet/liter solution was shown inadequate and three tablets/liter solution formed callus mis-formation.)

THE CUTTINGS

Leafy cuttings are taken from stock plants in the active growing state. There must be internal sap flow. Dormant cuttings are not used; there are limited metabolic activities and restricted sap flow and vascular uptake. Leafless cuttings have no 'leaf' entry points. Aqueous (water based) IBA solutions, using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets, are applied to leaves. The rooting solution enters the plant's vascular system through open pores in leaves through 'stomata' structures. Stomata are open in a temperature range about 60-90°F (16-32°C), provided cuttings are well hydrated. After entry into the vascular system, the IBA translocates to the basal end where it helps to initiate roots.

The rules for taking annual, perennial and woody plant cuttings are simple. Take leafy cuttings in the active growing state. Juvenile cuttings have better rooting capability compared to mature cuttings. For root formation, juvenile cutting require lower Rooting Solution rates than for mature cutting. To maintain juvenality, use 'cuttings-from-cuttings' when possible. For foliar methods, dormant or leafless cuttings, these are propagated by basal methods. Generally, cuttings that have nodes at the basal end do not root as well versus cuttings with inter-nodes. Some plant growers cut the

tips of large leaf cuttings to obtain more cuttings in a propagation tray. The cut causes a wound that is open to infection. Wounds in the tip area create competing 'sinks', which ties up valuable resources (metabolites) to heal the leaf wound, rather than induce root formation at the basal end.

FAVORABLE PROCEDURES

TEMPERATURE.

When using foliar methods it is important not to apply in cold propagation areas or use cold solutions. Cuttings taken from coolers must be brought up in temperature before treatment. The standard foliar application temperature range for cuttings and solutions should be about 60-90°F (16-32°C), provided the cuttings are hydrated.

When propagation is done in locations where day temperatures are high, spraying is done early in the morning after sticking when temperatures are cool. In south Florida, sticking is done during the hot time of day, with workers cooled under mist. Spraying is done early the day after sticking when temperatures are cool.

TIMING BETWEEN STICKING AND TREATMENT BY THE SPRAY DRIP DOWN METHOD.

Davies and Joiner's studies (1980) showed that there was a variation in rooting after several days between sticking and treatment. For example, it is best to use foliar auxin applications within the first 48 hours of sticking. There was a decline in rooting after waiting more than a week to treat with IBA rooting solutions. Hortus USA's trials determined that it is best to treat the same day, or the following morning, after sticking.

Many growers have found root formation increase when, after sticking, using three day sequential Spray Drip Down Method at the same rate each day. Perennial and woody ornamental develop improved roots when treated at about 750-1000 ppm IBA using Hortus IBA Water Soluble Salts solutions.

PERSONAL PROTECTIVE EQUIPMENT.

(Reference the product label for specific PPE)

When using the Spray Drip Down Method, treatment workers doing spraying must use appropriate PPE. It is best to spray while other workers are not in the production area. This may be done at the end of the work day when other workers are away. Workers who only stick do not require PPE since cuttings are untreated.

HYDRATION.

Cuttings should use well hydrated cuttings when using foliar methods. Wilted cuttings have closed stomata. The rooting solution must enter the leaf through open pores in the stomata. Solutions entry is within a few minutes after rooting solution application. Some European chrysanthemum propagators advise successful Spray Drip Down Method on slightly limp leaf cuttings. When using the Spray Drip Down Method, mist systems must be turned off before spraying. This reduces dilution of the rooting solution. After spray treatment, misters can be resumed after about 3/4 hour or until the rooting solution dries on the leaves

LABOR SAVINGS AND CONTROL.

Foliar methods have reduced labor cost; sticking batch treating cuttings is faster than individual hand sticking of cuttings by basal methods. Foliar methods have no 'misses' as may happen with basal dip methods. Foliar methods use lower rates, and reduced material cost, as compared with basal methods.

LEVELING CROPS BY SECONDARY APPLICATION.

To level crops, secondary weekly Spray Drip Down Method foliar applications are used on leafy cuttings in the active growing state, at rates similar to the first initial rate. First application may be any method.

For sequential day application, in this book see the article "Propagate Plants from Cuttings Using Foliar Applied Aqueous IBA Rooting Solutions. Tips: Do's and Don'ts", section "Sequential Treatment".

HYBRID PROPAGATION SYSTEMS.

Cuttings may be treated at time of sticking by any basal (Quick Dip, Long Soak, Dry Dip) or foliar (Spray Drip Down, Total Immerse) method. Then, the Spray Drip Down Method is used for second or third treatment; application will level crops.

Often growers will use either the Quick Dip, Long Soak, Dry Dip, Spray Drip Down, or Total Immerse Method to propagate some crops. Then, in parallel, use other method for other crops. Selection of the method can be dependant upon the plant variety, time of the year, or facility factors.

In a chrysanthemum propagation facility, it is common to hybrid operations. At the same or other times in the same facility, the Dry Dip Method (using dip rooting hormones) are used on some varieties; the Spray Drip Down Method (using rooting solutions) are used on other varieties.

ADVANTAGES OF FOLIAR APPLIED AQUEOUS (WATER BASED) IBA ROOTING SOLUTIONS

- Quality: Foliar methods produce high rooting quality due to uniform treatment.
- Low material cost: Foliar methods use low rooting solution rates and reduced material cost compared with the high rate basal Quick Dip Method.
- Low labor cost: Sticking by foliar methods use on third the labor of basal treated cuttings. Foliar methods have bulk treated cuttings. Basal methods have individually treated cuttings.
- Uniform rooting results: there are no misses. Spray Drip Down Meth treatment is done by skilled workers. Total Immerse Method is done in bulk.
- No cross contamination: The Spray Drip Down Method reduces cross contamination of diseases and pathogens; solutions are used one time.
- Reduced Personal Protective equipment: PPE is not required by workers doing sticking by the Spray Drip Down Method; no rooting solution is handled.
- Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets have zero hour Restricted Entry Interval (REI).
- Crops can be leveled: secondary spray application of the rooting solutions to planted crops can level crops.

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Growth Regulator Effects on Adventitious Root Formation in Leaf Bud Cuttings of Juvenile and Mature *Ficus pumila*¹

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Additional index words. indolebutyric acid, 6-(benzylamino)-9-(2-tetrahydropyranyl)-9H-purine, gibberellic acid, creeping fig

Abstract. Adventitious root formation was stimulated with foliar application of indolebutyric acid (IBA) from 1000 to 1500 mg/liter for juvenile and 2000 to 3000 mg/liter for mature leaf bud cuttings of *Ficus pumila* L. IBA increased cambial activity, root initial formation, and primordia differentiation and elongation. IBA stimulated rooting when applied to juvenile cuttings at 3, 5, or 7 days after experiment initiation, but had no effect on mature cuttings when applied at day 15, the final treatment period. The interaction of IBA/gibberellic acid (GA₃) did not affect early root development stages, but reduced root elongation and quality once primordia had differentiated. IBA/6-(benzylamino)-9-(2-tetrahydropyranyl)-9H-purine (PBA) inhibited rooting at early initiation stages.

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Recent researchers have generally agreed that adventitious root formation (ARF) involve sequences of histological steps with each step having different requirements for growth substances (5, 8, 9, 10, 11). Eriksen (5) and Mohammed and Eriksen (8) found that auxins and cytokinins had different effects on ARF depending on developmental stage. Sircar (11) reported 5 different histological stages in which GA₃ and IAA alternately promoted or inhibited ARF. Hypocotyl cuttings of herbaceous annuals have been used in previous sequencing

experiments, but herbaceous material may not give a true index of changes occurring in mature woody materials.

The woody ornamental creeping fig (*Ficus pumila*) exhibits strong dimorphism (2) and differences in rooting between the juvenile and mature forms. Objectives of this study were to determine the effect of IBA, PBA, and GA₃ applied at different rooting developmental stages to juvenile and mature leaf-bud cuttings (LBC) of *F. pumila*.

Materials and Methods

F. pumila cultivated on the University of Florida campus at Gainesville were used as stock plants. Leaf bud cuttings (LBC: lamina, petiole and 2.5 cm piece of stem with attached axillary bud) were rooted under an intermittent mist system in a medium of sterilized mason sand maintained at 24°C with a 2 hr night light interruption previously described (4). Juvenile LBC were harvested after 21 days and mature cuttings 42 days after experiments were initiated. All growth regulators were applied as aqueous sprays with 0.25 ml/liter of surfactant, emulsifiable A-C polyethylene and octyl phenoxy polyethoxy ethanol (Plyac).

In an experiment to establish optimum IBA concentration required for rooting, cuttings were taken in November and IBA applied at 500, 1000, 1500, 2000, 3000, and 10,000 mg/liter to juvenile and 2000, 2500, 3000, 4000, 5000, and 10,000 mg/liter to mature LBC at time of insertion. The design was a randomized complete block with 4 replications and 40 cuttings per treatment.

To characterize growth regulator effects at different root development stages a factorial experiment was initiated in May with 2 forms (juvenile, mature LBC) × 2 IBA pretreatments (control, treated) × 3 growth regulators (IBA, PBA, GA₃) × 3 application dates. An IBA spray of 1000 mg/liter was applied to half the juvenile cuttings and 3000 mg/liter to half the

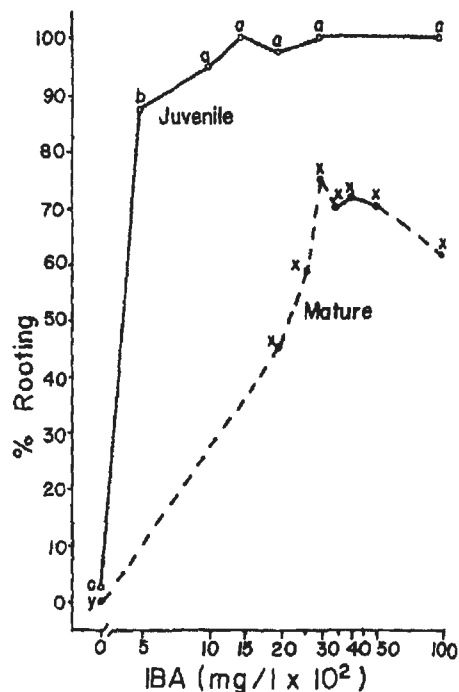


Fig. 1. Effect of IBA on rooting in juvenile and mature leaf bud cuttings of *Ficus pumila*. Points with same lower case letters are not significantly different.

mature material at the time of insertion. Growth regulators were then applied after 3, 5, or 7 days for juvenile and 3, 9 or 15 days for mature cuttings: IBA at 1000 mg/liter for juvenile and 3000 mg/liter for mature cuttings, 1000 mg/liter PBA and 3000 mg/liter GA₃ for both types. The design was a randomized complete block with 4 replications and 32 cuttings per treatment. To determine stage of ARF 10 cuttings of each treatment combination were selected at each of the 3 time intervals and fixed in formalin-acetic acid-ethanol (FAA) *in vacuo*, dehydrated in ethanol-tertiary butyl alcohol series and embedded in Paraplast-plus. Blocks containing stem pieces with one surface exposed were soaked in distilled water *in vacuo* for 5 days to soften tissues prior to sectioning. Serial cross and longitudinal sections were cut at 8 and 11 μ m and stained with safranin and fast green.

Cuttings were measured for percent rooting, root number, and root length (average of 3 longest roots) and rated on a quality scale of 1 to 4 with 1 = no rooting, 2 = small root system, 3 = intermediate root system and 4 = extensive root system.

Results

Optimum IBA concentration. IBA treatments stimulated ARF in both juvenile and mature LBC (Fig. 1, 2, 3, 4). At high IBA levels root length was reduced in both forms (Fig. 3) and root quality in juvenile cuttings was poor (Fig. 4). Best horticultural responses were obtained in juvenile material treated with 1000-1500 mg/liter and mature cuttings treated with 2000-3000 mg/liter IBA considering root number, length and quality (Fig. 2, 3, 4). The performance of IBA-treated juvenile LBC was better than IBA-treated mature cuttings.

Hormonal effects during rooting stages. Percent rooting in IBA pretreated cuttings was unaffected by additional IBA at any of the 3 time intervals after insertion, however, root length was reduced in all treatments (Table 1, 2). In juvenile LBC

receiving no IBA pretreatment, later IBA application increased rooting in all dates (Table 1), but in mature cuttings only the first or second application period was stimulatory (Table 2).

GA₃ reduced root length and quality in IBA-pretreated cuttings (Table 1, 2 and Fig. 5, 6). In juvenile cuttings without IBA pretreatment, GA₃ reduced root length (Table 1), but had no effect on mature LBC without IBA pretreatment (Table 2).

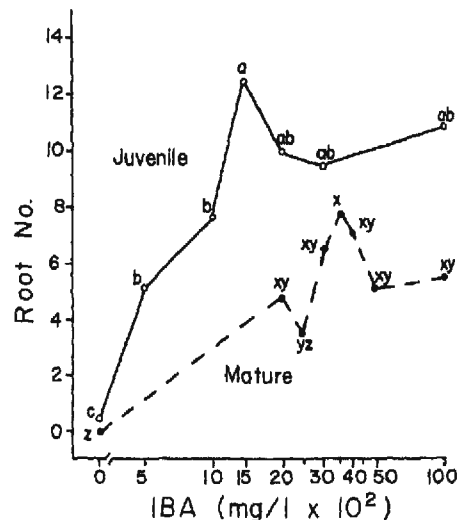


Fig. 2. Effect of IBA on root number in juvenile and mature leaf bud cuttings of *Ficus pumila*. Points with same lower case letters are not significantly different.

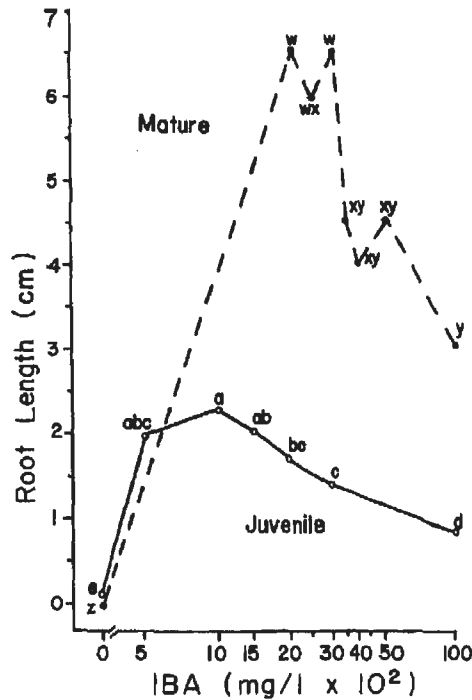


Fig. 3. Effect of IBA on root length in juvenile and mature leaf bud cuttings on *Ficus pumila*. Points with same lower case letters are not significantly different.

Table 1. Adventitious root formation in juvenile leaf bud cuttings of *Ficus pumila* treated with 3 growth regulators at 3, 5, or 7 days after experiment initiation. Half the cuttings were pretreated with 1000 mg/liter IBA.

IBA pre-treatment (mg/liter)	Growth regulator post treatment	Rooting (%)	No. roots	Root length (cm)	Root quality scale ^z
0	IBA (1000 mg/liter)				
	day 3	100a ^z	9.5e	1.1bcde	2.6de
	day 5	100a	11.0bcde	1.1bcde	2.8cd
	day 7	100a	10.3cde	1.0bcde	2.5de
	GA ₃ (3000 mg/liter)				
	day 3	31c	0.7h	0.8cde	1.3gh
	day 5	28c	0.8h	0.7de	1.3gh
	day 7	34c	1.0h	1.5bcd	1.5g
	PBA (1000 mg/liter)				
	day 3	0d	0h	0h	1.0h
	day 5	25c	0.9h	1.2bcde	1.3gh
	day 7	25c	0.9h	1.4bcd	1.3gh
	Control	31c	0.8h	1.7b	1.3gh
	1000	IBA (1000 mg/liter)			
day 3		100a	12.7b	1.5bc	3.0abc
day 5		100a	15.2a	1.3bcd	3.2ab
day 7		100a	12.4bc	1.0bcde	2.7cd
GA ₃ (3000 mg/liter)					
day 3		100a	10.8bcd	1.3bc	2.7cde
day 5		100a	9.0ef	1.5bc	2.8cd
day 7		100a	10.2de	1.7b	2.8bcd

PBA effectively limited ARF in IBA-pretreated cuttings when applied during the first or second time intervals (Tables 1, 2). In juvenile LBC the greatest inhibition occurred during the first time interval which coincided with increased cambial activity associated with the dedifferentiation phase of ARF (Table 3). PBA caused less inhibition of ARF the second appli-

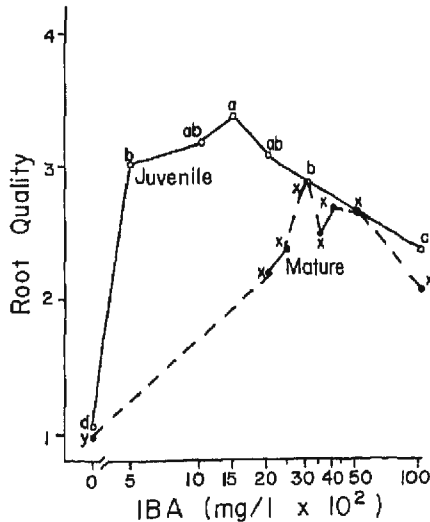


Fig. 4. Effect of IBA on root quality in juvenile and mature leaf bud cuttings of *Ficus pumila*. Points with same lower case numbers are not significantly different.

PBA (1000 mg/liter)				
day 3	38c	1.3h	0.5ef	1.4gh
day 5	66b	5.3g	1.3cde	2.0f
day 7	88a	7.2fg	1.2bde	2.3ef
Control	100a	11.9bcd	2.5a	3.4a

zRoot quality scale range from 1 to 4 with 1 = no root system, 2 = small root system, 3 = intermediate root system and 4 = extensive root system.
yMean separation in columns by Duncan's multiple range test, 5% level.

cation period when root initials and primordia were first observed. Half the LBC rooted by the third interval (Table 3); thus PBA application at this time did not affect % rooting but did reduce root number, length and quality. In mature cuttings PBA treatment at first application period completely inhibited ARF (Table 2) when no cambial activity was observed. PBA was less effective in inhibiting ARF during second application when cambial activity was first observed (Table 2, 4). Root length and quality were reduced with PBA application at any period, but had no effect on % rooting or number during the third treatment period.

PBA reduced rooting in juvenile cuttings not pretreated with IBA when applied during the first treatment period when neither root initials nor primordia were observed (Table 1, 3). In mature cuttings PBA had no statistical effect on rooting; however, none of the treated cuttings formed roots, nor were root initials or primordia observed (Table 2, 4).

Discussion

Mature *F. pumila* cuttings did not root as efficiently as juvenile material. Thus, IBA-treated mature cuttings required higher exogenous auxin levels and longer time to obtain

Table 2. Adventitious root formation in mature leaf bud cuttings of *Ficus pumila* treated with 3 growth regulators at 3, 9, or 15 days after experiment initiation. Half the cuttings were pretreated with 3000 mg/liter IBA.

IBA pre-treatment (mg/liter)	Growth regulator post-treatment	Rooting (%)	No. roots	Root length (cm)	Root quality scale ^z
0	IBA (3000 mg/liter)				
	day 3	84abc ^z	13.1abc	3.4ab	3.0ab
	day 9	94ab	8.6cde	3.0ab	2.7abc
	day 15	53cdefg	2.7fg	1.0cde	1.7efg
	GA ₃ (3000 mg/liter)				
	day 3	44efg	2.0fg	0.7de	1.5fgh
	day 9	41fg	1.9fg	0.8cde	1.5fgh
	day 15	38fg	1.1fg	0.8cde	1.4gh
	PBA (1000 mg/liter)				
	day 3	0h	0g	0e	1.0h
	day 9	0h	0g	0e	1.0h
	day 15	0h	0g	0e	1.0h
	Control	22gh	1.5fg	1.1cde	1.3gh
	3000	IBA (3000 mg/liter)			
day 3		81abcd ^z	11.1bcd	2.1bcd	2.6bcd
day 9		100a	16.1a	3.1ab	3.2ab
day 15		91ab	13.7ab	2.1bcd	2.7abc
GA ₃ (3000 mg/liter)					
day 3		66bcdef	8.4cde	1.6cd	2.0def
day 9		50defg	6.0ef	1.7cd	1.8efg
day 15		66bcdef	7.3de	2.2bc	2.1cde

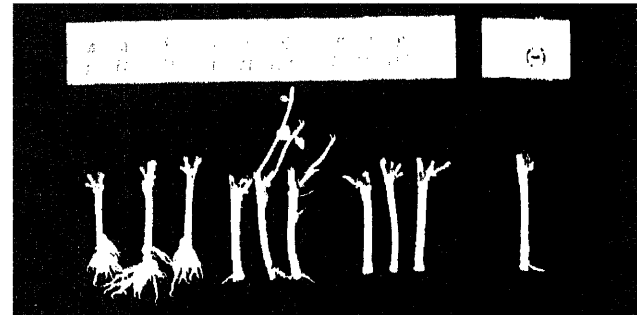
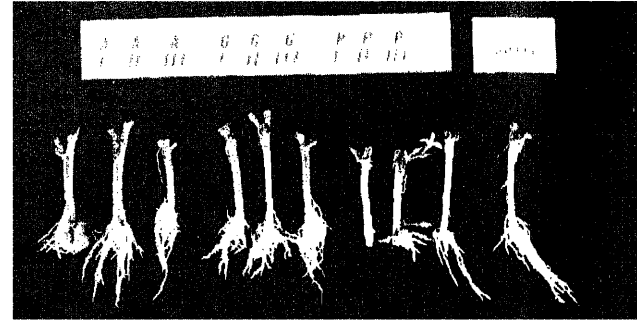


Fig. 5. Effect of IBA, GA₃ and PBA on adventitious root formation when applied at 3 time intervals to juvenile leaf bud cuttings. (top) Pretreated with (IBA). (bottom) No pretreatment with IBA.

PBA (1000 mg/liter)				
day 3	0h	0e	0e	1.0h
day 9	28gh	1.6fg	1.0cde	1.3h
day 15	75abcde	9.2bcde	1.3cde	2.2cde
Control	94ab	13.3abc	3.8a	3.2a

^zRoot quality scale ranged from 1 to 4 with 1 = no root system, 2 = small root system, 3 = intermediate root system and 4 = extensive root system.

^yMean separation in columns by Duncan's multiple range test, 5% level.

maximum rooting (3) than juvenile LBC. Mature cuttings may have lower endogenous auxin levels and/or other endogenous chemicals needed to stimulate root initiation. When ARF was measured on a daily basis (3), IBA-treated mature cuttings rooted slower than juvenile LBC, but equalled juvenile controls by day 20, giving strong evidence that endogenous auxin levels were acting as a possible limiting factor in root initiation.

IBA increased ARF in both juvenile and mature cuttings by stimulating initiation of cambial activity, root initials and primordia, which agrees with reports that auxins trigger early formation of root primordia (6). However in *F. pumila*, application of auxin above the optimum level reduced root length and quality indicating that primordia elongation was decreased.

In both juvenile and mature cuttings the combination of IBA/GA₃ retarded rooting after primordia were differentiated, since % rooting was not influenced but root length and quality were reduced. The conflicting reports on exogenous gibberellin influence on rooting (1, 7, 12) may be related to species differences. Our results agree with Hassig (7) who reported that initiating primordia were least affected by GA₃ but that cell number was reduced in older established primordia which was deleterious to root formation.

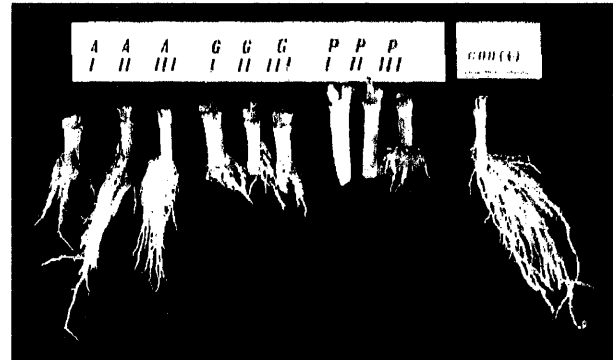


Fig. 6. Effect of IBA, GA₃ and PBA on adventitious root formation when applied at 3 time intervals to mature leaf bud cuttings. (top) Pretreated with IBA. (bottom) No pretreatment with IBA.

Table 3. Stage of adventitious root formation of juvenile leaf bud cuttings of *Ficus pumila* at 3 time intervals.

Treatment	Increased cambial activity	Root initials	Root primordia	Rooting (%)	No. roots	Root length (cm)	Root quality scale ^z
IBA pretreatment at (1000 mg/liter)							
day 3	yes	none	none	0	0	0	1.0
day 5	yes	yes	yes	0	0	0	1.0
day 7	yes	yes	yes	50	6.2	0.7	1.6
No IBA pretreatment							
day 3	none	none	none	0	0	0	1.0
day 5	yes	none	none	0	0	0	1.0
day 7	yes	yes	yes	20	0.4	0.5	1.2

^zRoot quality scale ranged from 1 to 4 with 1 = no root system, 2 = poor root system, 3 = intermediate root system and 4 = extensive root system.

Table 4. Stage of adventitious root formation of mature leaf bud cuttings of *Ficus pumila* at 3 time intervals.

Treatment	Increased cambial activity	Root initials	Root primordia	Rooting (%)	No. roots	Root length (cm)	Root quality scale ^z
IBA pretreatment at (3000 mg/liter)							
day 3	none	none	none	0	0	0	1.0
day 9	yes	none	none	0	0	0	1.0
day 15	yes	yes	yes	20	1.7	0.5	1.2
No IBA pretreatment							
day 3	none	none	none	0	0	0	1.0
day 5	none	none	none	0	0	0	1.0
day 15	yes	none	none	0	0	0	1.0

^zRoot quality scale ranged from 1 to 4 with 1 = no root system, 2 = poor root system, 3 = intermediate root system and 4 = extensive root system.

The rooting inhibition of PBA on juvenile and mature *F. pumila* concur with reports that cytokinins inhibit preinduction phases of rooting (12) with a loss of inhibitory effect at later stages (6).

Differences in adventitious rooting between juvenile and mature cuttings may be partially attributed to endogenous auxin levels, since lower IBA levels were required for optimal rooting in juvenile compared to mature LBC. However, other factors such as auxin/cytokinin and auxin/GA₃ ratios, cofactors and inhibitors may be involved, since exogenous IBA applications did not overcome root formation differences between IBA-pretreated juvenile vs. mature tissue.

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Aerial view Bailey Nurseries. Photo: Bailey Nurseries

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Auxin Application via Foliar Sprays[®]

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INTRODUCTION

Over the past six years Bailey Nurseries, Inc. has been delivering IBA (*indole-3-butyric acid*) to unrooted cuttings in a couple of ways; manual basal dips before planting and overhead sprays after planting is complete. Careful, repetitive trialing has shown us that many of the varieties respond equally as well to being sprayed with water soluble IBA after sticking instead of the traditional hand dip method that we have used for years. In both our Minnesota and Oregon propagation facilities the shift in delivery method has been driven by a desire to reduce our employees' exposure to chemicals, develop a more streamlined and sanitary approach to propagation and to reduce the labor costs associated with rooting hormone applications. All of these goals need to be met while maintaining our standards of high quality, well rooted cuttings. Using Hortus IBA Water Soluble Salts has helped us reach these objectives with many of our taxa.

MATERIALS AND METHODS

Cuttings harvested from our different production areas or bought from other suppliers are stored in our cold storage facilities and queued for planting. Our coolers are maintained at approximately 34 °F and 90% RH. By using water soluble IBA after sticking instead of dipping by hand this time in storage is reduced. After the cuttings are planted into the propagation trays or beds a single application of between 250 and 2000 ppm Water soluble IBA is made. This is done a variety of ways depending on the size of the area to be treated. For small areas a backpack type sprayer is used. For large areas a hose and reel type

sprayer with or without a boom style irrigator is utilized. The product literature recommends to "spray the solution evenly over the cuttings until drops go down to the media". We believe delivering 1L per 60ft² sufficiently meets these guidelines. Approximately 25-30 gal of solution is applied to 6000 ft². Mirroring our existing traditional IBA rates has been the starting point for our water soluble IBA trial rates. The product literature suggests using only distilled or de-mineralized water for these treatments to avoid precipitation problems. We feel this is not practical on such a large scale and have used well water since we began exploring this IBA delivery method.

Our results have shown that making these applications within 24 h of sticking is critical to our success. Typically the IBA is applied at the end of each day or first thing next morning when the light levels are low and the plants misting requirements are at a minimum. When cuttings have been treated with IBA during frequent misting cycles in the day no decline in efficacy has been noted. Applications that have been made several days after sticking have resulted in reduced final percentages and weaker, slower rooting in general.

The label identifies a zero re-entry interval and permits applications to be made while people are working in the houses. Waiting to treat the cuttings with IBA until the crews have finished planting and have left the house is a precautionary step that we feel more comfortable with. Each application is made by a specially trained and licensed pesticide applicator. Using only a select group of applicators reduces the number of employees who are in contact with chemicals. This helps ensure consistency and accuracy and limits the amount of chemicals our employees are exposed to. The required personal protection equipment is long sleeve shirt, long pants, shoes, socks and waterproof gloves. Posting the application with signage and/ or cones is unnecessary.

Implementing any new technique requires time and patience to be successful. The switch from manual dips to overhead sprays has proven time consuming but rewarding. Each variety needs to be thoroughly tested before we feel comfortable making a change to our production practices. The first trials consist of a 12-ft² section of cuttings to test for phytotoxicity and efficacy. Misting requirements have not changed with the use of this type of method. Blocks of trial plants are within the dipped sections, and are all given the same amount and duration of mist during the root initiation process. The cuttings are all weaned from mist at the same time. As our familiarity with the Hortus IBA Water Soluble Salts on a particular variety increases so does the size of the trial. If the first trial proves effective the trial area will be increased in proportion to the size of the crop, usually about 10%. After a second season of positive results the trial area will normally be increased to approximately one quarter to one half of the crop. Multiple crop locations and sticking times allow us to expedite the trial process. It is only after three separate trials have occurred with successful results that the practice can become standard in our production methods.

RESULTS

As our experience with this application method has grown so has the use of Hortus IBA Water Soluble Salts. Familiarity and repetitive success has given us comfort with this product. Over the last several years the percentage of crops treated with IBA after sticking has risen steadily. This past season the amount of cuttings treated with IBA after sticking increased sharply. Currently 95% of our softwood crops in MN that call for IBA are receiving overhead IBA sprays after sticking. 100% of our MN evergreen propagation is now slated to be treated this way also. In OR we treated approximately 20% in 2007. We anticipate the percentage of cuttings treated with IBA after sticking in Oregon to increase significantly as our trial numbers and confidence in this method build

Table 1. Cuttings treated v. application method from 2003 to 2007 in MN

Treatment	2003	2004	2005	2006	2007
Hand dipped (%)	99.62	95.6	91.95	86.1	5.16
Overhead spraying (%)	0.38	4.4	5.08	13.82	94.84

Using water soluble IBA after sticking has streamlined our propagation process dramatically by reducing the number of employees needed to treat cuttings with IBA. In 2007 approximately 8 million cuttings were propagated in MN from May 15th to Aug 15th. 79% required some form of IBA treatment. Another 5.2 million were produced in OR, of which 100% required an IBA treatment. Crews of 8-10 people have historically been responsible for treating these cuttings with IBA during this time. Using IBA after planting has reduced handling and storage time in the cooler and has freed up members of our propagation team to do other tasks. During the winter and at other times of the year we run similar crews for evergreen propagation and other softwood propagation schedules.

This method has also given us some piece of mind regarding stem burn and the possibility of contamination. Cuttings treated with overhead IBA applications are not exposed to alcohol. Concerns over the years on whether or not exposing the stems to solutions containing alcohol has contributed to some of the rot on some of the cuttings are moot. By using a formulation of IBA that is water soluble we can eliminate the possibility of alcohol burning or drying out the basal portion of the stems. Using water soluble IBA after the cuttings have been placed in the greenhouse provides us some comfort by eliminating the possible cross contamination issues associated with dipping cuttings in a stock solution. The transfer of pathogens in a communal solution of hormones is not a concern with this method.

A majority of the crops treated with Hortus IBA Water Soluble Salts react identically to cuttings treated with traditional IBA. Rooting and top growth are monitored throughout the season and carefully evaluated at harvest time to determine root mass and overall plant quality. Acer, Berberis, Cornus, Diervilla, Euonymus, Forsythia, Hydrangea, Juniperus, Lonicera, Philadelphus, Physocarpus, Rhus, Rosa, Spiraea,

symphoricarpos, Syringa, Thuja, Viburnum and Weigela crops are all large genera Bailey Nurseries grow that respond well to overhead IBA applications. They are all currently, or are scheduled to be receiving Hortus IBA Water Soluble Salts as their sole form of IBA in MN. Currently all Hydrangea, Spiraea and symphoricarpos are treated with IBA after sticking in OR. Clethra, Cornus, Forsythia, Hamamelis, Ilex, Philadelphus, Viburnum, and Weigela are all in the final stages of trial and should be added to the treat all after sticking list for the 2008 season in OR.

While similar rooting time and subsequent root and shoot development is most commonly seen, differences have been noted on several varieties. This varies from slight, subtle differences to results that have caused us to discontinue water soluble IBA and continue with the traditional propagation method. Some varieties have shown a preference to the traditional hand dip method in conventional IBA and some vice versa. Several varieties have exhibited growth differences with the over the top spray technique in multiple trials. Amelanchier, Aronia, Rosa, symphoricarpos, et al. tend to slow down their vegetative growth early on following the overhead application method. Vegetative growth and flowering is usually delayed by approximately one to two weeks. This is not discernible later on as plants are grown for several months after rooting and mowed back repeatedly to maintain height and promote branching before harvest. This season Forsythia and Philadelphus crops treated with IBA after sticking in OR looked better than the hand dipped control. Cuttings within the trial blocks initiated roots more quickly and responded with darker green, more vigorous top growth. Root mass increased significantly also. Some Viburnum varieties have developed adventitious aerial roots from leaf nodes above the soil line when Hortus IBA Water Soluble Salts are applied to the cuttings. During the first two seasons all varieties of Betula cuttings in OR responded well to the overhead applications of IBA. This season many petioles were twisted at the 500 and 1000 ppm rates. An explanation as to why this seasons' trial acted differently than in previous years escapes us.

In multiple trials many of the Prunus and Rhododendron varieties have not rooted as well when treated from above after sticking at our Oregon facilities. Root initiation has been slowed and final percentages have been significantly lower in previous trials. Rhododendron and Prunus cuttings in OR have now been removed from the future trial list. Prunus *besseyi* 'Pawnee Buttes' responds well to overhead IBA applications in MN and currently receives IBA in this manner.

Switching IBA delivery from the traditional hand dip method to overhead applications trades relatively high labor costs and low chemical costs for relatively high chemical costs and low labor costs. Treating cuttings with IBA after sticking is helping us reduce hormone application expenses. Wages for 8-10 people working 8-h days, over a ten week period add up quickly. Conversely using kilograms of water soluble IBA is expensive too. One 6000 ft² greenhouse contains approximately 90,000 softwood cuttings when spaced at 2-³/₄". It takes approximately 8 people

3.75h, or 30-labor hours to treat this many cuttings with IBA by hand. Applying water soluble IBA after the cuttings have been stuck takes an applicator approximately 1h to prepare, transport to and from the application site, apply and clean the spray equipment when finished. Chemical costs of water soluble IBA for an equivalent number of cuttings at 750 ppm equal approximately \$74. The cost of traditional IBA needed to dip 90,000 softwood cuttings is approximately \$16.

Our next step to further reduce the costs associated with the application of rooting hormones has been to apply lesser rates of water soluble IBA. For the past two seasons we have invested a lot of time evaluating the effect of halving many of the rates we commonly use. Surprisingly we have noticed very little difference in the outcome of these trials. All cuttings are given the same quantity and duration of mist and are grown side by side the cuttings that have been treated with a full rate. It has taken the same time for plants to begin root initiation and the subsequent growth has developed at a similar pace. This year we have looked at reducing rates even further by quartering the initial rate. If the normal rate was 1000 ppm we have begun treating the cuttings with 250 ppm after sticking. To date these trials have looked very promising also. When the trails are complete we hope to have established an optimal IBA rate for each of the varieties we grow. The goal of these trials is to produce the highest quality rooted cutting with the least amount of IBA possible.

DISCUSSION

Using Hortus IBA Water Soluble Salts has helped us reduce our employee's exposure to chemicals. Limiting the number of employees who apply hormones in the greenhouses to a small group of trained, licensed chemical applicators gives us a more consistent, accurate application that we feel more comfortable.

By applying water soluble IBA after sticking our labor hours associated with treating cuttings with IBA have declined significantly. Our cuttings now spend less time in cold storage and in the preparation room where problems associated with lengthened exposure to temperature, humidity and/ or handling can occur. Plants are not grouped and dipped together into a solution where pathogens may be transferred. Cuttings are not exposed to alcohol which may contribute to cuttings drying out and possibly being burned or damaged.

Significant financial savings have resulted from using this method of IBA delivery. Spraying the cuttings after they have been stuck instead of dipping them before frees up planting crews for other work. On average, treating a crop with Hortus IBA Water Soluble Salts after sticking has allowed us to save approximately \$0.038 per ft². Further rate reduction trials have looked promising and may help increase these savings in the future.



Hortus IBA

Water Soluble Salts®

(20%)

Plant Rooting Hormone

Dissolve Salts in Water to Make Rooting Solutions. Use by FOLIAR and BASAL Methods on Plants that can be Propagated from Cuttings. Use on Annual, Perennial & Woody Ornamental Plant Cuttings.

Ingredients:

Active ingredients
Indole-3-butyric acid 20.0%
Other ingredients 80.0%
Total 100.0%

Registered by
Hortus USA Corp., NY NY 10011

Made in Holland

EPA Reg No. 63310-22
EPA Est No. 63310-HL-001

Net Weight: 2 Pounds, 4 Ounces (1 Kilo)

KEEP OUT OF REACH OF CHILDREN
CAUTION

See Attached Label for First Aid and Precautionary Statements



Use Hortus IBA Water Soluble Salts (20%) to make rooting solutions. The Salts dissolve easily in water to over 100,000 ppm IBA. Use the solutions to propagate new plants from cuttings. Treated cuttings are expected to produce uniform roots all around the basal end.

**PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS.**

CAUTION

Causes moderate eye irritation. Harmful if inhaled or absorbed through the skin. Avoid contact with eyes, skin, ingestion or inhalation. Avoid breathing dust (vapor or spray mist). Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash before reuse.

PERSONAL PROTECTIVE EQUIPMENT

Applicators and other handlers must wear: long sleeve shirt, long pants, shoes, socks and waterproof gloves. For exposure in enclosed areas or outdoors, use a dust/mist filtering respirator (MSHA/NIOSH approval number prefix TC-21C, or a NIOSH approved respirator with any N, R, P or HE filter) when mixing solutions, or when spraying solutions on cuttings by the Spray Drip Down Method. When treating cuttings by the Quick Dip, Long Soak and Total Immerse Methods, use of a filtering respirator is not required. No PPE is required after cuttings are inserted into media.

USER SAFETY RECOMMENDATIONS

Users should: Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

FIRST AID Classification of Pesticide: Plant Growth Regulator	
If in eyes	<ul style="list-style-type: none"> > Hold eyes open and rinse slowly with water for 15-20 minutes > Remove contact lenses, if present after the first 5 minutes then continue rinsing eye > Call a poison center or a doctor for further treatment or advise
If on skin or clothing	<ul style="list-style-type: none"> > Take off contaminated clothing > Rinse skin immediately with plenty of water for 15-20 minutes > Call a poison center or a doctor for further treatment or advise
If swallowed	<ul style="list-style-type: none"> > Call a poison center or a doctor for further treatment or advise > Have person sip water if able to swallow > Do not induce vomiting unless told to do so by the poison control center or doctor. > Do not give anything by mouth to an unconscious person.
If inhaled	<ul style="list-style-type: none"> > Move person to fresh air > If person is not breathing call 911 or an ambulance, then give artificial respiration, preferably by mouth to mouth, if possible > Call a poison center or a doctor for further treatment or advise
NOTE TO PHYSICIAN: May cause moderate eye irritation which will last a short time. This product does NOT contain any petroleum, caustics or active solvent products	
Have the product container or label with you when you call a poison control center or doctor or going for treatment. You may call 800-325-3055 or 314-770-0717. 7:30AM-5PM CST Mon-Fri or the National Pesticide Information Center (NPIC) at 1-800-858-7378	

You may also call 800-325-3055 or 314-770-0717 for an MSDS. 7:30AM-5PM CST M-F

ENVIRONMENTAL HAZARDS

For terrestrial uses: Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning of equipment or disposal of equipment wash waters or rinsate.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with labeling. For any requirements specific to your State or Tribe, consult the State or Tribal agency responsible for pesticide regulation.

AGRICULTURAL USE REQUIREMENTS
<p>Use this product in accordance with its labeling and with the Worker Protection Standard, 40 CFR 170. This Standard contains requirements for the protection of agricultural workers on farms, forests nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this labeling about personal protective equipment and restricted-entry intervals. The requirements in this box only apply to the uses of this product that are covered by the Workers Protection Standard (WPS).</p> <p>Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.</p> <p style="text-align: center;">THE RESTRICTED-ENTRY INTERVAL (REI) FOR THIS PRODUCT IS "0" HOURS.</p>

RATE DETERMINATION

A wide solution rate range is indicated for this product. Your ideal rates will vary according to specific plant variety, season, quality of the cuttings, and local growing conditions. Prior to large scale production, test a few plants at several rates within the range. If foliar application causes phytotoxicity, try basal applications and/or decrease rates. Use the lowest rate to produce the desired effect.

PREPARING A HORTUS IBA WATER SOLUBLE SALTS® (20%) SOLUTION USING WATER

1) Weigh the required amount of Hortus IBA Water Soluble Salts.

Measure by weight not volume.

2) Use tap water at about 65-90F; measure less than the final volume.

3) Mix: dissolve Hortus IBA Water Soluble Salts in the water.

- If precipitation occurs with tap water then dissolve in distilled, demineralized, or filtered water.
- Do not dissolve Hortus IBA Water Soluble Salts in solvents other than water.

4) Add water to the mixing container to bring the solution to the final volume.

5) Apply the solution by the selected method.

6) After use, dispose of the solution as described in the 'Storage and Disposal' statements on this label.

- For the Total Immerse and basal methods, dispose of solutions between plant lots to avoid cross contamination.
- Stock solutions can be made in any concentration, to over 100,000 ppm IBA, using Hortus IBA Water Soluble Salts mixed in water.

AMOUNT OF HORTUS IBA WATER SOLUBLE SALTS® REQUIRED

- Hortus IBA Water Soluble Salts contain 20% IBA.
- 1 gram technical IBA = 5 grams Hortus IBA Water Soluble Salts
- Note: 1 gram = 0.035 ounce

LIQUID VOLUME CONVERSION:

liters to gallon: grams Salts /liter x 3.78 = grams Salts /gallon

LITERS: To get 1000 ppm IBA: dissolve 5 grams of Hortus IBA Water Soluble Salts in water to make 1 LITER

GALLONS: To get 1000 ppm IBA: dissolve 19 grams of Hortus IBA Water Soluble Salts in water to make 1 GALLON

HOW TO MAKE RATES FROM 100 TO 10,000 PPM IBA USING HORTUS IBA WATER SOLUBLE SALTS®

ppm IBA	Weight of HORTUS IBA WATER SOLUBLE SALTS	
	grams per liter of water	grams per gallon of water
100	0.5 grams	1.9 grams
200	1.0	3.8
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
800	4.0	15
900	4.5	17
1,000	5.0	19
5,000	25.0	95
10,000	50.0	190

PROMOTE ROOTING OF PLANT CUTTINGS

Use to propagate new plants from cutting, from those easy to root to the most difficult to root.

EASY STEPS

- Take plant cuttings, usually stem cuttings.
- For woody cuttings usually wound by making a 3/4" long notch at basal end.
- Apply solutions to plant cuttings by the methods listed below. (Do not apply the dry Salt powder to the plant cuttings.)
- Take care of cuttings as appropriate for the plant variety. Control watering, temperature, humidity, light and other environmental factors. Observe and control external factors such as insects and fungus.
- Use the minimum concentration to achieve results; excess concentration may inhibit root formation.

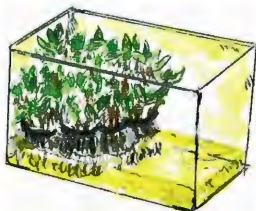
BASAL METHODS FOR USE ON CUTTINGS IN THE GROWING SEASON AND ON DORMANT WINTER CUTTINGS

BASAL LONG SOAK METHOD

Use on cuttings in the growing season and winter dormant cuttings.

- Immerse basal end of cuttings approximately 1" in solution for 12 to 48 hours.
- Stick immediately or store.

Trial Rates are ppm IBA using Hortus IBA Water Soluble Salts



Trial Rates are ppm IBA using Hortus IBA Water Soluble Salts

	Trial Rates
Hard to root annuals and perennials	25-100
Herbaceous cuttings	50-200
Woody ornamental cuttings, grape, roses	50-400

QUICK DIP METHOD

Use on cuttings in the growing season and winter dormant cuttings.

- Immerse basal end of cuttings approximately 1" in solution a few seconds.
- Stick immediately or store.

Trial Rates are ppm IBA using Hortus IBA Water Soluble Salts



Trial Rates are ppm IBA using Hortus IBA Water Soluble Salts

	Trial Rates
Annuals, soft perennial, tender cuttings from ornamental plants, tropical house plants	80-200
Herbaceous, perennials, pot roses cuttings	150-1500
Difficult to root herbaceous, perennials, tropical hose plant cuttings	500-1500
Softwood cuttings	500-1500
Hardwood cuttings	500-2000
Difficult to root hardwood cuttings (Avoid high rates by using the Basal Long Soak Method)	2000-10,000

FOLIAR METHODS FOR USE ON LEAFY CUTTINGS IN THE GROWING SEASON



TOTAL IMMERSE METHOD

Use on leafy cuttings in the growing season

- Total immerse the cuttings in the solution for about 5 seconds. A basket is useful.
- Stick immediately or store.



SPRAY DRIP DOWN™ METHOD

Use on leafy cuttings in the growing season

- Stick cuttings.
- Spray the solution on leaves and stems until the solution drips down into media.

TRIAL RATES FOR THE TOTAL IMMERSE AND SPRAY DRIP DOWN™ METHODS

Trial Rates are ppm IBA using Hortus IBA Water Soluble Salts

	Trial Rates
Annuals, perennials, chrysanthemums	80-250
Herbaceous and hard to root perennial plant cuttings	250-1500
Woody ornamental cuttings	300-1500



IMPROVE PLANT GROWTH

Use on rooted plants and leafy plant cuttings in the growing season to develop uniform crops, when propagating plants from cuttings after sticking by any method, or when transplanting.

- Method: Spray Drip Down™ Method: Spray the solution onto the leaves of plants until the solution drips down.

- Rates: Use the Spray Drip Down™ Method trial rates listed above. Use the lowest concentration to produce the desired effect.
- Frequency: Weekly or until the required results are achieved.
- Trials: Do small trials prior to doing large scale production.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage and disposal.

Pesticide Storage

Store in a cool dry place under lock and key. Post as a pesticide area. Always store pesticides in the original container. Store away from food, pet food, feed, seed, fertilizers, and veterinary supplies. Place liquid formulations on lower shelves and dry formulations above.

Pesticide Disposal

To avoid wastes, use all material in this container by application according to label directions. If wastes cannot be avoided, offer remaining product to a waste disposal facility or pesticide disposal program (often such programs are run by state or local governments or by industry).

Container Handling

Nonrefillable container. Do not reuse or refill this container. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling if available, or puncture and dispose of in a sanitary landfill or by incineration. Do not burn unless allowed by state and local ordinances.

WARRANTY

It is warranted that this product conforms to the chemical description on the label thereof and is reasonably fit for purposes stated on such label only when used in accordance with the directions under normal use conditions. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness or other unintended consequences may result because of such factors as weather conditions, presence of other materials, or the manner of application all of which is beyond the control of Rhizopon b.v. or Hortus USA Corp. To the extent consistent with applicable law, Rhizopon or Hortus USA shall not be liable for consequential, special or indirect damages resulting from the use or handling of this product. To the extent consistent with applicable law, all risks shall be assumed by the buyer. Rhizopon or Hortus USA make no warranties

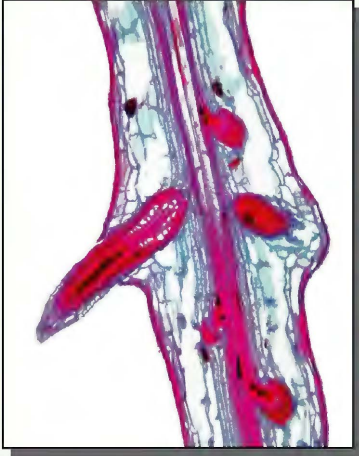
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Technical Support & Articles:
rootinghormones.com

ON-LINE CALCULATOR:
Find the measured weight of
Hortus IBA Water Soluble Salts
for any ppm or liquid volume
<http://hortus.com/calculatesalts.htm>



Hortus

Plant Propagation from Cuttings

A Guide to Using Plant
Rooting Hormones by
Foliar & Basal Methods

Third Edition

Plant Propagation from Cuttings produces new plants identical to stock plants. Rooting Hormones are essential to develop roots on cuttings. This Guide describes five successful foliar and basal propagation methods. The methods use the rooting hormones Hortus IBA Water Soluble Salts® (rooting solutions) & Rhizopon® AA (rooting solutions & dry powders).

**The World's Finest Rooting Products by
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