Hortus
Plant Propagation from Cuttings

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

Joel Kroin

Hortus USA Corp.
New York

First Edition
2009

Dedicated to
Chizuko and Mari
and Kees, a great scientist and teacher

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Hortus Plant Propagation from Cuttings, a guide to using plant rooting hormones by foliar and basal methods

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Preface

Growers have propagated plants for thousands of years. They first needed to produce food crops. As civilization progressed, they cultivated ornamental plants. In the 1890's L. H. Bailey summarized methods to propagate plants and identified reproduction characteristics. Three quarters of a century ago researchers identified the natural and synthesized plant rooting substances (auxins). The usefulness of these substances opened new methods of propagation. Still, Bailey's observations of when to take cuttings, and the type, are necessary for successful use of the auxins.

Much has been learned about auxins including their metabolism (manufacture), translocation (motion), storage and effectiveness to do many kinds of plant growth regulation. Delivery of the auxin through the leaves, stems, and buds have proven success for many needs. There have been many studies about the entry of plant growth substances into the plant structure. As an entry point for auxins to induce root formation many growers had adopted basal methods. In 1985, putting these facts together, Kees Eigenraam, at Rhizopon in Holland, identified the foliar method of application of auxins. The methods were quicky adopted by many large plant growers. To prove the growers' success, the time is right for the academic researchers to perform trials on foliar methods of application.

Growers say that their crops are 'different' from either Yoder-Greenleaf's perennial plants or Bailey Nurseries' ornamental plants. From a rooting standpoint, if the cuttings are selected from the stock plant at the proper time, the rooting response is similar. This book uses L. H. Bailey's idea of observation to decide how to propagate plants from cuttings. Depending upon the quality of the stock plant, plant variety and physiological state of the cuttings, selecting the method of application is possible. Growers commercially propagate thousands of plant varieties from cuttings; putting the plants in list form would have been difficult. The rate charts in this book are for typical plants; growers should select the method and rates for similar plants and conditions.

This book is intended to be read in sections. Some content is repeated to assure understanding each section.

Two people contributed indispensable information for this book. Kees Eigenraam has been my mentor, teacher and inspiration. His keen observations of plant growth have led to many innovative plant growing techniques. I thank Sam Drahn, the lead researcher at Bailey Nurseries. Sam took upon the challenge to use foliar methods, making them work in new ways.

I recognize the growers at Yoder-Greenleaf, Lancaster, PA, who have done thousands of rooting trials on many varieties. Knowing plant propagation is an art, they call their trials, 'works in progress'. I appreciate the editorial assistance of many friends, especially Cliff Hoogland and James Grouzos.

Joel Kroin
New York City, 2009

Introduction
Plant Propagation from Cuttings

Plant explorers have always taken on the challenge to improve their plant growing techniques. The plant scientist L. H. Bailey wrote the Nursery Book, first published in 1896. He presented successful plant growing and propagating techniques that may be considered archaic by today's growers. Yet, Bailey listed hundreds of plant varieties that could be successfully propagated using the means the growers had at the time. (1) Growers today look to the best way to grow plants according to their needs and abilities.

Viburnum. Photo: Bailey Nurseries

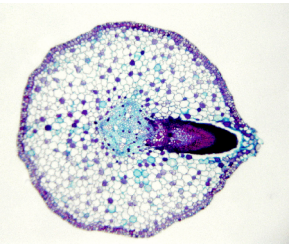
For propagation, Bailey identified the proper time of the year to take cuttings from the plant. He knew that selection of plant cuttings that were juvenile, physiologically young, are more likely to produce adventitious roots than older plants. What he did not know was the plant makes rooting co-factors; plants naturally produce substances that help induce root formation.

When Bailey wrote his book, other scientists were making observations about the motions of substances within plants that could induce root formation, flower forming and other plant processes. Charles Darwin and Frits Went had studied phototropism bending in grass blades. This led them to ideas about the plant generating substances that moved within the plant and produced effects in other parts of the plant.

In 1934 Went and Thimann, at Caltech in California, observed "the rootforming substances appear to be fairly widely distributed in nature" (2). The natural substance, later called auxin, is IAA (*Indole-3-acetic acid)*. Thimann proved that auxin promotes cell enlargement, cell division, root initiation and other plant growth functions. After the discovery of IAA, Zimmerman, Hitchcock and Wilcoxin, at the Boyce Thompson Institute, in Yonkers NY, investigated bio-simulators of the natural auxin. IBA *(Indole-3-butyric acid)* and NAA *(Naphthalene acetic acid)* were both identified as useful and more stable then IAA to induce root formation.

Boyce Thompson's early publications say that the first trials to apply auxins were to the basal end of the cuttings. The basal end is a logical

place to apply as that is where plants need roots. It has been known that *leaves* are a point source of auxin. Though leaves are a point source of auxin, scientists have rarely studied application of auxin through the leaves, to induce root formation.



Micro-photograph: Root origin. Cross section cut. Photo: Hortus USA.

By 1939 Dutch plant researchers at Amsterdam Chinene Factory (ACF) became interested in the newly discovered auxins. Likely they wanted to improve the propagation of the trees that they used to synthesize quinine. They produced end-use rooting products under the name Rhizopon (named for the fungus *Rhizopus suinus*, a producer of IAA), and developed commercial methods of use.

In 1985, Cornelius (Kees) Eigenraam, the Rhizopon senior researcher, found that rooting solutions applied to the foliage of leafy plant cuttings, in the growing season, produce roots at the basal end. He had known that the Rhizopon products were useful when applied to plant portions above the soil line for plant growth regulation. Leaf drop and fruit holding were typical uses. He developed the spray drip down and total immerse methods used on herbaceous and woody ornamental plants. He also found that foliar application improves root formation of slow to root cuttings.

Eigenraam's methods were first used by Dutch and German growers to propagate herbaceous plant cuttings like chrysanthemum and pot roses. The first commercial uses of foliar methods were limited geographically; the scientific community was slow to become aware of them. By the 1990's Hortus USA registered, and introduced to US growers, the Rhizopon products along with the foliar methods. In 1998, Hortus developed Hortus IBA Water Soluble Salts used to make water based rooting solutions at high concentration. Used by foliar methods, rooting solutions made with the Rhizopon products and the Hortus salts can root many kinds of cuttings.

US growers like Yoder-Greenleaf Perennials and Bailey Nurseries propagate plants from cuttings use water-based rooting solutions by foliar application. They make fresh water soluble IBA rooting solutions with Hortus IBA Water Soluble Salts. They can also use Rhizopon AA Water Soluble Tablets. Yoder-Greenleaf Perennials produce perennial plants. Bailey Nurseries produce hardy ornamental plants, annuals and perennials. While their plant crops, equipment used, and growing conditions are different, they use the same method of application with similar application rates.
Yoder and Bailey use the Spray Drip Down Method when they propagate plants from cuttings in the growing season. First they stick the cuttings.

Yoder-Greenleaf stick cuttings in flats in the greenhouse and Bailey mostly stick their cuttings in beds. The cuttings are kept hydrated. They do their rooting solution treatment, either the same day, the morning of the following work day, even after a weekend. The time also fits into their production schedule. They do their application at a time when the leaf stomata are open; this allows absorption of the rooting solutions. The stomata close when the temperature is too hot or cold. Therefore, they prefer a morning application. They have adapted their spray equipment for their facilities. Yoder-Greenleaf made a custom spray cart and Bailey uses commercial hydraulic sprayers. Their treatment procedure is simple. First they make rooting solutions using Hortus IBA Water Soluble Salts. They use mix tank spray equipment not proportional mixers. When ready to apply, they turn off their misters. Their trained application people spray the rooting solution onto the leaves of their cuttings until liquid drips down from the leaves. If the leaves are wet from mist, they use an excess of solution to overcome dilution. They turn misters on after the solution dries on the leaves (at least 3/4 of an hour). After treatment they resume their normal operations.

Basal methods have been used to apply rooting hormones since the 1930's. Both rooting solution and dry powers have continued use. They are easy to use. They can be used on many plant varieties that can be propagated from cuttings. The dry dip method is favored by many growers. A versatile method, basal quick dip method is used on herbaceous through hardwood cuttings. Going back to basics, to original basal rooting techniques, the basal long soak method is effective to overcome propagation problems with difficult to root cuttings.

This book describes five methods to propagate plants from cuttings. Two types of plant rooting products are used by the methods: dry powders using Rhizopon AA #1, #2 & #3 dry powder rooting hormones, and rooting solutions using Rhizopon AA Water Soluble Tablets and Hortus IBA Water Soluble Salts. Growers should try different methods as appropriate for their plants and facility.

REFERENCES

(1) Bailey, L. H. (1896). The Nursery Book. New York: Macmillan.
(2) Went, F., and Thimann, K. 1934. On the chemical nature of rootforming hormones. Proceedings Royal Acad. Amsterdam. Vol XXXVII. Pages 456-9.

YODER BROS.

This book refers to "**Yoder**" and "**Yoder-Greenleaf Perennials**". When **Yoder Brothers, Inc.** began using **Hortus IBA Water Soluble Salts** their perennials plants were sold as **Yoder-Greenleaf Perennials**. In October 2008, Syngenta bought Yoder's mum and aster business and the **Yoder** brand name. In July 2009 Yoder Brothers began using the name *Aris*. Green Leaf Perennials is now called *Green Leaf Plants*.

History of the Rhizopon® and Hortus USA Plant Rooting Products

RHIZOPON AS AN EARLY PRODUCER OF PLANT ROOTING PRODUCTS

Historic photograph. Rhizopon NAA and IAA dry powder rooting hormones and water soluble tablets used to make solutions. From the 1940's. Photo: Rhizopon

During the 1930's plant hormones were identified. In 1939 the Dutch Amsterdam Chinene Factory, ACF, started production of auxin, plant rooting hormone, end use products. Using the trade name Rhizopon, their earliest products were dry powder rooting hormones and water soluble tablets used to make rooting solutions. Their first and current products contain one auxin, using IAA, IBA or NAA. Rhizopon tablets, still in production, are unique. From their beginning, Rhizopon introduced an integrated system of products and techniques. Being located in the heartland of the Dutch plant growing area, their products were put into greenhouse and nursery production. In early years, their products were used for propagation by basal methods. In 1985, Rhizopon introduced foliar methods using their rooting solution products.

RHIZOPON CONNECTION WITH HORTUS USA

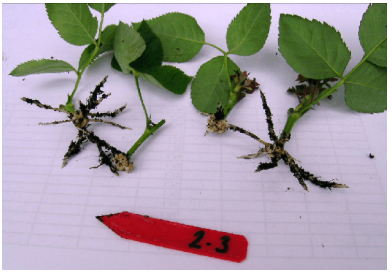
In 1989, Rhizopon bv, then an independent company, became affiliated with the US company Hortus USA Corp. Hortus USA registered several of Rhizopon's IBA containing products with the US EPA: Rhizopon AA #1, #2, and #3 dry powder rooting hormones, and Rhizopon AA Water Soluble Tablets. The dry powders are used by the traditional dry dip method. The Tablets are dissolved in water to make rooting solutions. Dry powder rooting hormones and rooting solutions have long been used by basal methods. New to many US growers, Hortus USA introduced growers to the Rhizopon foliar methods using rooting solutions. One of the first growers introduced was Yoder Brothers. Yoder adapted the method to their Yoder-Greenleaf Perennial operations. Soon after, Bailey Nurseries did their own studies on the foliar spray method; they adopted it for use on most of their ornamental and perennial plants.

HORTUS IBA WATER SOLUBLE SALTS DEVELOPMENT

Based upon US grower needs, in 1998, Hortus USA formulated a new water soluble IBA containing product, Hortus IBA Water Soluble Salts. The Salts are used like Rhizopon AA Water Soluble Tablets. The Salts can be made into higher concentration solutions than the Tablets. The result is that a wider range of plants can now be propagated by the foliar and basal methods.

Rhizopon® Rooting Guide: Introduction

C. (Kees) Eigenraam. Rhizopon Rooting Guide.
Rhizopon b.v. Hazerswoude, The Netherlands.



Pot roses treated with Rhizopon rooting hormones. Photo: Rhizopon

Every day, the technical advisors from Rhizopon visit nurseries that propagate plants from cuttings. These nurseries seek the latest plant growing trends and techniques. The plant market demands that growers produce increasingly large shipments, of high quality, with uniform plant development, delivered on schedule, and at low price.

Growers can trace many production problems to inferior quality cuttings. The growers must use a perfect system to maintain their stock plants to produce high quality cuttings. They must use the best rooting techniques suitable for the plants and adapt to the facility.

An important principle: A GOOD START, HAVING GOOD CUTTINGS, IS NECESSARY FOR SUCCESSFUL PRODUCTION.

Hedera (Ivy). Holland. Stock plants on top. Production plants on bottom. Photo: Hortus USA

SELECT THE BEST POSSIBLE STOCK PLANTS

Years ago, simply taking cuttings of plants growing here and there at the nursery was common practice. Frugal growers even took cuttings from plants in public landscape areas. Naturally, and especially in the latter case, knowing the condition of the stock plant was impossible. Since the best stock plants produce the best cuttings, finding a good source, or to grow them at the growers' own nursery is essential. During each growing cycle, growers must select plants that exhibit the best growth characteristics; the best plants are used as stock plants.

SELECT THIN CUTTINGS

The location at which growers take the cuttings greatly affects the speed at which the cuttings will root. From the selected plants, take cuttings close to the base of the plant. When taking cuttings from varieties that are difficult to root, selecting the thinner cuttings is advisable. Thin cuttings will root more easy than thick cuttings.

Specially designed rooting tunnel, Eindhoven, the Netherlands. Photo: Rhizopon

GROW STOCK PLANTS UNDER CONTROLLED CONDITIONS

Raising the selected stock plants under ideal, controlled conditions is important. When growers give their stock plants exactly what they need, these plants will produce “super cuttings.”

ADVANTAGES OF TISSUE CULTURE

Cuttings taken from stock plants produced from tissue culture often produce better cuttings than 'ordinary' stock plants. The resultant stock plants produced by meristem culture are free of viruses.

Only well-rooted cuttings can produce a good final product.

Bailey Nurseries propagation house. Photo: Bailey Nurseries

Stock plants for tree propagation. Hazerswoude, the Netherlands. Photo: Rhizopon

RAPID ROOTING IS PREFERABLE

Cuttings that root rapidly will exhibit good growth habits. After root formation the cuttings produce their own store of carbohydrates and are resistant to disease.

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 *(CO^2)* and OXYGEN.

LIGHT

The propagation house should regulated so that the cuttings are not under direct sunlight. The effect of direct sunlight and the resultant heat effect will cause stress to the cuttings.

Pot rose propagation. Germany.
Photo: Hortus USA

Light is necessary for photosynthesis. Un-rooted cuttings are not able to engage in much photosynthesis; a small amount of light, 100-125 um 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

Water for a plant is just as important as blood for a human. A plant must have a good root system in order for it to absorb water. A supply of 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 black rot. **A very dry substrate encourages callus formation. Although many believe that callus is beneficial for root formation, this is not true. Callus hinders and slows root formation.**

Environmental control of the propagation beds. Holland. Photo: Rhizopon

Growers can 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 grower determines if the trays have the proper weight for the “the proper moisture level.” Provide water based on these observations.

CARBON DIOXIDE *(CO^2)*

Photosynthesis is important for cuttings. Photosynthesis requires sufficient carbon dioxide (CO^2), light, and water. An advantage of an increased level of CO^2 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 CO^2 level *(800-1000 ppm)* will form roots better.

OXYGEN

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.

Specially designed rooting tunnel. Eindhoven, the Netherlands. Photo: Rhizopon

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.

TEMPERATURE

To prevent excess transpiration, controlling the temperature is important. The soil temperature has a very direct influence on the speed of rooting. A soil temperature ranging between 68-77˚F *(20-25˚C)*, is ideal during the initial rooting stage. After this initial stage, growers can allow the temperature to drop a few degrees. 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. Aerial growth will come later.

There is a relationship between light and temperature. During the winter, when there is a low level of natural light, with no artificial lights, use a lower temperature. Cuttings will die if they are at temperatures about 74˚F *(23˚C)* with a short day and low light levels. The cuttings rooting activity in the soil will out pace it's ability to do photosynthesis induced by the light level.

Evaluating rooting trials. Holland. Photo: Rhizopon

INSPECTION

It is essential for growers to inspect their crops on a regular basis. Records should be made on the production methods, materials used, and source and quality of the stock plants and cuttings.

Inspection of plant roots. Propagation house at Bailey Nurseries. Yamhill, Oregon. Photo: Bailey Nurseries

Evaluating Rhizopon rooting trials. Boskoop Research Center. Boskoop, Holland. Photo: Rhizopon

ROOTING REGULATOR

Some cuttings can form roots without receiving a treatment of a root promoting hormone. It is valuable to use a rooting hormone on all kinds of plants that can be propagated from cuttings- from easy to difficult to root. The proper use of rooting hormones allows the cuttings to form roots in a shorter amount of time and with more uniformity.

Speedy root formation is important. With fast root development, the cuttings can better absorb water on their own. “Better rooting” means the cuttings form roots all around the stem. The roots must cover several centimeters at the base. The cuttings should not just form a single root at random. Only well-rooted cuttings can develop into top-quality plants.

Hortus IBA Water Soluble Salts® and Rhizopon® AA Plant Rooting Products

Products used by the Dry Dip Method

METHOD

Dry Dip Method

ZERO HOUR REI

US EPA registered label has WPS ZERO HOUR re-entry interval (REI).

RHIZOPON AA DRY DIP ROOTING HORMONES ARE ALWAYS FRESH. THE POWDERS ARE READY TO USE.

Rhizopon® AA #1

(US EPA registration # 63310-19. Active ingredient 0.1% IBA).

Pink Color Powder.

Use on easy to root cuttings

Rhizopon® AA #2

(US EPA registration # 63310-20. 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

(US EPA registration # 63310-21, Active ingredient 0.8% IBA)

White Color Powder.

Use on more difficult to root cuttings

Products used to make Rooting Solutions

Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets are formulated with *IBA* to be soluble in *ORDINARY WATER*. Rooting solutions made with these products can be used by ANY methods where technical *IBA, K-IBA & Premixed* Rooting Solutions are used, at the same or lower rates.

METHODS

Basal Quick Dip Method
Spray Drip Down Method
Total Immerse Method
Basal Long Soak Method

ZERO HOUR REI

US EPA registered label has WPS ZERO HOUR re-entry interval (REI).

GROWERS ALWAYS HAVE FRESH SOLUTIONS. ROOTING SOLUTIONS ARE MADE USING ORDINARY WATER.

Hortus IBA Water Soluble Salts®

(US EPA registration # 63310-22. Active ingredient: 20% IBA)

Measure the Salts using a scale then mix into ordinary water.
The Salts are water soluble to over 100,000 ppm IBA.
The rooting solutions are buffered close to pH neutral.
The Salts remain in solution to any concentration.

Rhizopon® AA Water Soluble Tablets

(US EPA registration # 63310-8, Active ingredient: 20% IBA, 50mg IBA/Tablet)

Measure by counting Tablets then mix into ordinary water.
The Tablets are water soluble to 1000 ppm IBA.
Tablets are useful when a scale is not available to measure and mix small amounts of rooting solution.

Making Rooting Solutions

HORTUS IBA WATER SOLUBLE SALTS®

Measure the Salts using a gram scale. Mix with water to make rooting solutions in the desired concentration. The Salts are soluble in ordinary water to over 100,000 ppm IBA. The Salts are always measured by weight, never by volume. When a scale is not available use Rhizopon AA Water Soluble Tablets.

RHIZOPON®AA WATER SOLUBLE TABLETS

The Tablets are pre-measured; count and mix with ordinary water to make rooting solutions in the desired concentration. An electric hand blender is helpful to dissolve many Tablets. The Tablets can be made into rooting solutions up to 1000 ppm IBA. (Above 1000 ppm IBA use Hortus IBA Water Soluble Salts).

MAKING UP A CONCENTRATED ROOTING SOLUTION

A premix Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets rooting solution concentrate can be added to the production tank where the water is added to the proper level.

TEMPERATURE

The best mixing temperature is in the range 60-90°F; dissolving is slower at low temperatures.

METRIC SYSTEM

Use the metric system when calculating the ppm IBA for Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets rooting solutions. The system allows for easy calculation of liquid volume to concentration.

WETTING AGENTS

Use of wetting agents has not been established.

WATER IS USED TO MADE ROOTING SOLUTIONS

Water is the natural fluid in plants. Rooting solutions made with ordinary water assures *no "alcohol burns"*, as may occur with tech. IBA dissolved in alcohol or from pre-mixed/alcohol solutions.

Converting Rates

The rates for rooting solutions in this book and on the Hortus IBA Water Soluble Salts label are listed as **ppm IBA** (parts per million IBA). Some books on plant propagation list ppm IBA for their suggested IBA basal quick dip rates. The rate chart below gives the weight of Salts or number of Tablets required make ppm water soluble IBA rooting solutions. Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets can be used interchangeably in rates below 1000 ppm IBA; above 1000 ppm IBA use the Salts.

Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets rooting solutions can be used in every case where IBA, K-IBA or premix rooting solutions are used.

CONVERSION: ppm IBA to TABLETS to SALTS

- 1 Tablet of Rhizopon AA Water Soluble Tablets (contains 50 mg IBA) which yields 50 ppm when dissolved in 1 liter of water.
- 1/4 gram (0.25 grams) of Hortus IBA Water Soluble Salts (contains 50 mg IBA) yields 50 ppm IBA when dissolved in 1 liter of water.
- **50 ppm IBA ⇨ 1 TABLET/liter ⇨ 0.25 GRAMS OF SALTS/liter**
- **Measure salts by weight not by scoop (sold by weight not volume)**

Parts per million IBA (ppm IBA)	RHIZOPON AA WATER SOLUBLE TABLETS # Tablets/liter of water	HORTUS IBA WATER SOLUBLE SALTS LITERS # grams of Salts/liter of water	HORTUS IBA WATER SOLUBLE SALTS GALLONS # grams of Salts/gallon of water: 1 gal = 3.8 liters
50 ppm IBA	1 Tablet per liter	0.25 gm of Salts per liter	.95 gm of Salts per gallon
100	2	0.5 gm	1.9 gm
200	4	1.0 gm	3.8 gm
250	5	1.25 gm	4.75 gm
300	6	1.5 gm	5.7 gm
400	8	2.0 gm	7.6 gm
500	**10**	**2.5 gm**	**9.5 gm**
750	**15**	**3.75 gm**	**14.25 gm**
1000	**20**	**5.0 gm**	**19 gm**
1500	Use Salts	7.5 gm	28.5 gm
2000		10.0 gm	38 gm
2500		12.5 gm	47.5 gm
3000		15.0 gm	57 gm
4000		20.0 gm	76 gm
5000		25.0 gm	95 gm
6000		30.0 gm	114 gm
7000		35.0 gm	133 gm
8000		40.0 gm	152 gm
9000		45.0 gm	171 gm
10,000		50.0 gm	190 gm

Hortus IBA Water Soluble Salts

Water Soluble to Over 100,000 ppm IBA

ROOTING SOLUTIONS MADE USING ORDINARY WATER

Rhizopon AA Water Soluble Tablets

Pre-measured - Count and Mix

Rhizopon AA Dry Powder Rooting Hormones

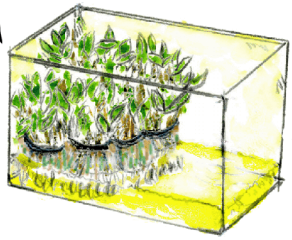
READY TO USE DRY POWDER ROOTING HORMONES

The Most Popular Concentrations

SPRAY DRIP DOWN METHOD

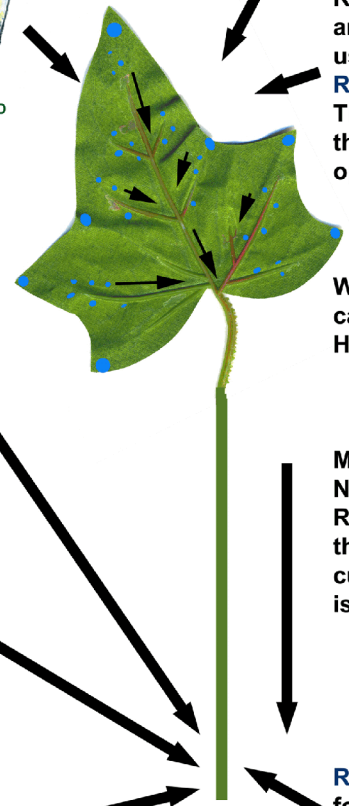
TOTAL IMMERSE METHOD

BASAL QUICK DIP METHOD



BASAL LONG SOAK METHOD

BASAL DRY DIP METHOD



NATURAL ROOTING HORMONES are produced in the **LEAVES** of plants

Rooting Hormones are applied to leaves using **WATER based ROOTING SOLUTIONS**. The Hormones enter the plant through open stomata

Water is the natural carrier for Rooting Hormones

Mass Flow moves the Natural and Applied Rooting Hormones to the **BASAL END** of the cutting. The Basal End is a sink point

ROOTS are induced to form at the Basal End by action of the Natural and Applied Rooting Hormones

Storage and Keeping of Dry Products and Rooting Solutions

STORAGE OF DRY PRODUCTS

Rhizopon AA #1, #2 & #3 Dry Dip Rooting Hormones, Rhizopon AA Water Soluble Tablets, and Hortus IBA Water Soluble Salts are sold dry. Store the products in their original sealable containers that have the original label. Rhizopon AA Water Soluble Tablets and Hortus IBA Water Soluble Salts are sensitive to humidity; keep them dry to avoid caking and difficulty to dissolve. Long term, store in dark. Store the dry products at room temperature; they do not require refrigeration. If kept dry, at normal room temperature, the dry products will be fully active for many years.

CARE AND KEEPING OF ROOTING SOLUTIONS

Make rooting solutions by dissolving the Rhizopon AA Water Soluble Tablet and Hortus IBA Water Soluble Salts using ordinary water. Hard water may reduce solubility. If the Tablets and Salts fully dissolve then the active ingredient is in solution. Avoid using untreated water from lakes and wells; organics in the water may that may biologically decay the IBA. **The labels read: *"Mix a portion of the solution for the same day use. Dispose of the unused portions."* Dispose of solutions in un-labeled containers to avoid misidentification.**

The Spray Drip Down Method uses the solution one time. Since organic material has not contaminated the solutions, the unused solutions can be kept several days for the next treatment. Growers sometimes use solutions for the Basal Quick Dip, Total Immerse, Basal Long Soak Methods on more than one production lot. It is best to use fresh solutions between production lots to avoid cross contamination of pathogens. Dispose the used solutions at the end of the production day. Do not store the used solutions; the active ingredient will biologically decay.

Tests on Rhizopon AA Water Soluble Tablet and Hortus IBA Water Soluble Salts solutions, stored in the dark, at 68°F, after 5 days were at full strength. Other trials found IBA solutions kept under light and at room temperature did not lose strength for several weeks. Solutions are light amber color when mixed; there may be a color change over time to dark amber does not effect the strength.

CARE AND KEEPING OF DRY POWDER ROOTING HORMONES

Rhizopon AA #1, #2 & #3 dry dip rooting hormones are ready to use. Always take out from the stock container enough powder for current needs. Do not return the used portion to the stock container since the active ingredient be contaminated. Dispose of the used portion.

Methods in Brief

FOR SOLUTION METHODS- Make rooting solutions using Rhizopon AA Water Soluble Tablets or Hortus IBA Water Soluble Salts.

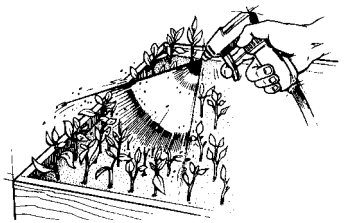
FOR THE DRY DIP METHOD- Use Rhizopon AA #1, #2 and #3 Dry Dip Rooting Hormones.

FOLIAR METHODS

Foliar methods are used for cuttings that are leafy and are in the growing season. Foliar methods are not used on dormant cuttings.

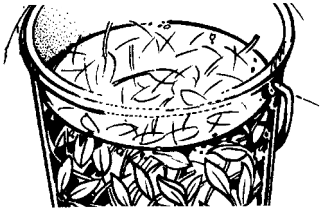
Foliar methods ONLY use rooting solutions that are made using water. Solvents used to dissolve IBA or pre-mixed alcohol based rooting solutions will dehydrate and kill plant cells.

SPRAY DRIP DOWN METHOD



- Make a rooting solution using Rhizopon AA Water Soluble Tablets or Hortus IBA Water Soluble Salts.
- Stick the untreated cuttings in the media.
- Spray the rooting solution onto leaves until the liquid drips down the leaf into the media.
- After application wait until the solution dries, or at least 3/4 hour (nominal), before turning on misters or sprayers.
- Resume normal production.

TOTAL IMMERSE METHOD



- Make a rooting solution using Rhizopon AA Water Soluble Tablets or Hortus IBA Water Soluble Salts.
- Total Immerse the cuttings into the solution for a few seconds.
- Stick the cuttings in media.
- Dispose of the used solution.
- Resume normal production.

Graphics: Rhizopon

BASAL METHODS

Basal methods are used for cuttings that are leafy and are in the growing season, on leafless cuttings, and on dormant cuttings. Woody cuttings often need to have wound cuts made at the basal end before treatment. Herbaceous cuttings are not wounded.

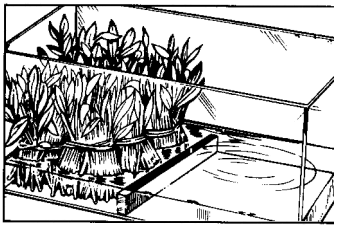
DRY DIP METHOD

- Take off enough Rhizopon AA #1, #2 or #3 Dry Dip Rooting Hormones powder from the stock container for the current propagation session.
- Dip the basal end of the cuttings about a half inch into the power.
- Stick the cuttings in media.
- Dispose of the used powder.
- Resume normal production.

BASAL QUICK DIP METHOD

- Make a rooting solution using Rhizopon AA Water Soluble Tablets or Hortus IBA Water Soluble Salts.
- Immerse the basal end of the cuttings into the rooting solution for a few seconds.
- Stick the cuttings in media.
- Dispose of the used solution.
- Resume normal production.

BASAL LONG SOAK METHOD



- Make a rooting solution using Rhizopon AA Water Soluble Tablets or Hortus IBA Water Soluble Salts.
- Soak the basal end of the cuttings into the rooting solution about 12 to 24 hours (nominal).
- Stick the cuttings in media at any time.
- Dispose of the used solution.
- Resume normal production.

Graphics: Rhizopon

Basics of Taking Plant Cuttings

Growers usually take plant shoot cuttings from plant growth of the current growing season. The range of cuttings is from herbaceous to hardwood. Stating one type of cutting which is useful for all plants is not possible. Herbaceous cuttings from annual and tropical plants can be taken at any time. Deciduous and evergreen plant cuttings can be taken in early Summer through early Fall. Dormant hardwood cuttings can be taken in the Fall or during the Winter.

THE 'BEST' TIME TO TAKE CUTTINGS

Many variables influence the rooting of cuttings. Plants have different rooting ability at different times of the year. The difference of a few weeks in taking of cuttings may produce success or failure. After a certain age, often years, some plants may even have difficulty producing cuttings able to produce roots.

JUVENILE CUTTINGS

Cuttings taken from the juvenile parts of many plants have better ability to produce roots compared to older parts. The juvenile cuttings require lower rooting hormone rates compared to the older cuttings. To maintain the juvenility, annual and perennial plants are often propagated from young stock plants. Plants like chrysanthemum are often rotated twice a year. The cuttings taken from the current stock plants are used for new plant production and also to make the next generation of stock plants.

CARE OF CUTTINGS

The cuttings must be taken from the best stock plants with good light and fertilization provided before the cuttings are taken. Growers should propagate plant cuttings taken during the growing season soon after being cut. This is not always possible for perennial and annual cuttings. Many of these cutting are produced in off-shore stock plant production facilities. When shipped, cuttings must be kept chilled during transit. The shippers use special cartons that protect the cuttings from temperature variation, The cuttings are packed in plastic bags to assure continued hydration. Shipping time must be short to assure prompt arrival at the rooting facility. Certain plants do not ship well. They must be propagated soon after being taken; they are grown at or near the rooting faculty.

Winter cuttings are often taken in the Fall, kept in plastic, stored in cold storage, and planted out in the Spring.

WOUNDING

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

Cutting Types and Methods

Type of cuttings used by different methods of application	Dry Dip	Spray Drip Down	Basal Quick Dip	Total Immerse	Basal Long Soak
LEAFY CUTTINGS • ornamental plants • herbaceous plants ***In the Growing Season.***	✓	✓	✓	✓	✓
LEAFLESS CUTTINGS • ornamental plants • herbaceous plants ***All Year Including Winter Cuttings.***	✓		✓		✓
• EASY-TO-ROOT **• HARD-TO-ROOT CUTTINGS** ***In the Winter.***	✓		✓		✓

Basal and Foliar Methods

BASAL APPLICATION	**DRY DIP METHOD**	**Dry Dip Powder.** Dip basal end in rooting powder then stick. *(Powders stay on cuttings a long time)*	**RHIZOPON AA #1, #2 & #3** Dry Powder Rooting Hormones *(Use dry; not to make rooting solutions)*
	BASAL QUICK DIP METHOD	**Rooting Solution.** Dip basal end in rooting solution then stick.	**RHIZOPON AA WATER SOLUBLE TABLETS** *or* **HORTUS IBA WATER SOLUBLE SALTS** *(Use to make rooting solutions)*
	BASAL LONG SOAK METHOD	**Rooting Solution.** Dip basal end of cuttings in rooting solution about 12 to 24 hours (nominal) then stick.	
FOLIAR APPLICATION	**SPRAY DRIP DOWN METHOD**	**Rooting Solution.** Stick then spray leaves of cuttings with rooting solution until the solution drips down.	
	TOTAL IMMERSE METHOD	**Rooting Solution.** Totally immerse cuttings in rooting solution then stick.	

Cutting Types

Stem cuttings are out-growing stems, mature sprouts or tip cuttings. Many types of stem cuttings may be taken.

Softwood cuttings are from the fast growing soft tips of stems, usually in the Spring.

Herbaceous cuttings, sometimes called tip cuttings or shoot cuttings, are 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. Softwood and herbaceous characteristics in cuttings are favored for the foliar methods to apply rooting solutions. When selecting cutting types for foliar applied rooting solutions, further sub-divisions of “herbaceous” can be made:

- ***Tender annual plant cuttings***
- ***Tender perennial plant cuttings***
- ***Hardy perennial plant cuttings***
- ***Tender woody plant cuttings***

Greenwood cuttings are from the soft tip or stem after the spring growth has slowed down. The stem is somewhat harder and woody than the soft wood cutting.
Semi-ripe cuttings are taken during the late summer after the annual growth has slowed down. The stem is harder than soft wood or green wood cuttings.
Hardwood cuttings are from dormant fully mature stems, usually from the current years growth.

The following types of cuttings are also used in plant propagation.

Scion cuttings are dormant 'ligneous' woody twigs.
Eye cuttings are pieces of foliated or defoliated stalks with one or more eyes.
Root cuttings are part of the root, usually annual. These are taken from certain plants which have the capacity to regenerate stems from root parts.
Leaf cuttings are from parts of the leaf. New roots develop at the base or veins of the cutting.

Perennials and Annuals
Handling Un-Rooted Cuttings

HANDLING UN-ROOTED CUTTINGS FROM OUTSIDE VENDORS.

Stick cuttings promptly.
Minimize wilting during rooting.
Use appropriate rooting hormones by effective methods.
Practice good sanitation.
Provide temperatures in a range from 65-75°F (nominal)

SHIPMENTS- HANDLING UN-ROOTED CUTTINGS

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 at below freezing temperatures. Stick the un-rooted cuttings as soon as possible 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 warmer temperatures.

ROOTING OF CUTTINGS USING ROOTING HORMONES

Use a plant rooting hormone treatment to increase rooting uniformity.
Some easy to root plant cuttings do not need treatment.
The following methods are suitable for annual and perennial cuttings.

Foliar Methods

- **Spray Drip Down Method (using rooting solutions)**
- **Total Immerse Method (using rooting solutions)**

Basal Methods

- **Basal Quick Dip Method (using rooting solutions)**
- **Dry Dip Method (using dry powder rooting hormones)**

Products to Make Rooting Solutions

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

Products used by Dry Dip

- **Rhizopon AA #1 For easier to root plant cuttings. Useful for annual and perennial cuttings**
- **Rhizopon AA #2 All purpose. For intermediate to root cuttings. Useful for annual and perennial cuttings**
- **Rhizopon AA #3 For more difficult to root plant cuttings.**

MEDIA

Stick cuttings as soon as possible into pre-moistened, well drained, soil-less media with 5.5- 6.5 pH. Do not stick garden mum cuttings into dry media since it is a sure way to reduce its initial growth and future potential.

STICKING DEPTH

Stick the cuttings just deep enough that they are anchored by the medium, normally 1/4 to 1/2 inch depth.

TRAY SIZE

Tray sizes range from 36 to 128 cell. The longer you plan to hold the cuttings in the cell tray before planting, the bigger the cell should be. Proper handling in the cell tray is critical.

DIRECT STICKING

Un-rooted cuttings can also be direct stuck to the finishing container. Finishing containers generally require more space than trays.

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 check plant growth, reduce the bud breaking action, or cause severe budding.

MISTING GUIDELINES

Apply mist immediately and frequently to maintain turgidity and minimize wilting while roots develop.

1-3 DAYS AFTER STICKING	• Mist during daylight hours in all stages and the night for the first 3-4 days to helps to keep the cuttings turgid for optimum rooting. • Mist 10 seconds every 5-10 minutes.
4-7 DAYS AFTER STICKING	• Callus is being formed. • Mist 10 seconds every 20 minutes.
8-15 DAYS AFTER STICKING	• 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	• Cuttings can be ready to plant.

LIGHTING AND AIR TEMPERATURE CONTROL

Light is necessary to root un-rooted cuttings. The ideal light levels are 3200-3800 foot-candles. The rooting medium temperature should be maintained from 68-75˚F (nominal). The air temperature should be maintained from 70-85˚F (nominal). Use long day lighting year round to reduce budding during rooting.

FERTILIZATION

Follow fertilizer label instructions. Un-rooted cuttings should be fertilized during propagation. Apply a complete N-P-K fertilizer. Use a fertilizer containing 300 ppm of nitrogen approximately 2 to 3 times a week starting on the third day after sticking or when callus is starting to form. Cuttings should be planted as soon as possible after rooting. 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.

Typical rooting station for annual and perennial plants.

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.

EXPECTED TIME FOR ROOT FORMATION

Most herbaceous plant cuttings root within two weeks.

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 minimize its harmful effects.

FUNGUS CONTROL

Follow label instructions.
For fungus disease control apply appropriate fungicides.

INSECT CONTROL

Follow label instructions.
For insect control apply appropriate insecticides

Always perform your own trials for your own plants in your own facility.

REFERENCES

Rhizopon Rooting Guide. Rhizopon, Hazerswoude, Holland.
Yoder Garden Mums and Asters (2008-2009). Yoder Brothers, Barberton OH, USA.
Yoder Handling Un-rooted Perennials (2004). Yoder Brothers, Barberton OH, USA.

Dutch Chrysanthemum Propagation

The photographs were taken in Dutch chrysanthemum propagation house that uses ROBOTS. Specialized carriers are used by robots. The robots position the carriers into the fixed locations on the greenhouse floor. The robots can be programmed to apply Rhizopon rooting solutions by the Spray Drip Down Method.

After Rhizopon dry powder rooting hormone treatment. Photos: Rhizopon

Sticking chrysanthemum, Cuttings are either pre-treated with rooting solutions or powder, or untreated for later Spray Drip Down treatment.

Transport robot shown, in rear,
The robot can pickup and place the carrier trays, automatically treat the cuttings using the Spray Drip Down Method, and cover the trays with plastic..

Chrysanthemum propagation house in Holland that uses robots.

Well rooted chrysanthemum ready for shipment after 12 days

Hardwood Cuttings

Hardwood cuttings are taken from the fully mature stems of deciduous shrubs and trees. Stock plants for these cuttings require careful selection and preparation before the cuttings are taken. Pruning of the stock plants allow them to produce new growth early in the growing season. The new growth has good ability to produce roots. Cuttings are taken at the end of the growing season or during the dormant season.

The cuttings do not have leaves and don't perform photosynthesis. They do not require stringent environmental control. If cuttings are taken before the dormant buds break they need protection by keeping them in cold storage; this prevents growth of leaves before root formation. Stored unprotected, hardwood cuttings will dry out; the cuttings should be kept in plastic bags.

When Fall cuttings are planted, they should first be treated with rooting hormones by basal methods. After, the cuttings are planted as deep as possible. The cuttings should be protected using cold frames or other methods.

Application of rooting hormones to the basal end of hardwood cuttings improves the quality of new roots. Some plant varieties will only produce roots if they receive a rooting hormone treatment. Two types of rooting products are used on dormant hardwood cuttings:

> **Dry dip rooting hormones**, Rhizopon AA #2 and #3, are used by the Dry Dip Method.
> **Rooting solutions** are made using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. The solutions are used by the Basal Quick Dip and the Basal Long Soak Methods.

IMPROVING ROOTING SUCCESS

If roots do not form, some growers unsuccessfully apply 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. High rooting hormone concentrations may inhibit root formation. For difficult to root cuttings, the Basal Long Soak Method can replace the Basal Quick Dip or Dry Dip Methods.

The basal ends of the cuttings are soaked, about one inch into the solution, for 12 to 24 hours (nominal). Timing is not critical. The cuttings slowly absorb the rooting hormones. The plant stores the rooting hormones at the basal end where it slow releases them for root formation. After treatment in the Fall, the cuttings can be kept in cold storage and planted out in the Spring, or, they can be treated before planting.

Foliar Method: Basics

Using foliar methods, rooting solutions are applied to the leaves of plants during the growing season. Foliar methods are not for use on dormant or leafless plant cuttings, or when plant growth has slowed. Two methods are used: the Spray Drip Down and the Total Immerse Methods. The rates used for the two methods are the same for most plant varieties. The methods can be used interchangeably.

MODE OF ACTION

Water based rooting solutions are applied to leaves of plants. *Alcohol based rooting solutions are never used; they can cause burns and plant mortality.* The 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. The rooting hormones are stored at the basal end; they are slow released by the plant to induce root formation.

PRODUCTS USED TO MAKE WATER BASED ROOTING SOLUTIONS

Hortus IBA Water Soluble Salts
Rhizopon AA Water Soluble Tablets

USE ON MANY TYPES OF PLANT CUTTINGS

Foliar applied rooting solutions add a new dimension to the categories of plant cuttings. Annual plants, and many perennial plants, have a soft cell structure that never becomes woody. Plant cutting types used by foliar application of rooting solutions:

- Tender Annuals.
- Tender Perennials.
- Hardy Perennial.
- Tender Woody.
- Hardy Woody.

Tender annual and perennial cuttings plant cuttings are more sensitive to rooting solutions than hardy cuttings. Tender cuttings can tolerate narrower range of useful foliar rates that the hardier ones. Too high a rate, for either tender or hardier, may cause a leaf curl, marginal leaf curl, brown spotting overall, dark or light leaf discoloration, aerial roots, or roots on one side of the cutting. When new leaves grow in they will be normal. *Strong root mass is often a benefit from slightly elevated rates from the 'normal' rate.*

Foliar Spray Drip Down & Total Immerse Methods

For foliar methods of application there is no apparent difference in rooting solution activity when using the Spray Drip Down Method or the Total Immerse Method. For small leaf cutting either method is useful. The Total Immerse Method gives uniform solution coverage for large leaf cuttings.

A homogenous crop, such a single plant variety from one greenhouse, will not have a cross contamination problem. Either the Spray Drip Down or Total Immerse Method can be used.

The Total Immerse Method uses the solution in a tank that can be used on many production lots. Where different plant varieties from different growing facilities are to be treated the cuttings should be segregated to prevent cross contamination of pathogens

Total Immerse Method
The solution can be applied to one crop during a treatment session. Dispose the used solutions.

Spray Dip Down Method
The solution can be applied to many crops during a treatment session. Unused solutions can be used at a later treatment session.

FACTORS EFFECTING FOLIAR METHODS

Stock plant preparation: "pumping up the stock plants"
Leaf spotting and curl are usually caused by inadequate stock plant preparation. The 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.

Genetics
Genetics can influence the rooting reactions; some cultivars may respond differently to the same rooting solution application rate. Sometimes genetic variations cause spotting and curl. These effects can be reduced by using the rooting solution at a lower rate. When leaf curl, leaf spotting occurs, the plants will out grow the problem when new leaves form. Rarely occurring, genetic variations may also cause side rooting.

Adjusting the Foliar Rate
When applying rooting solutions by foliar methods, use as low a rate as possible to achieve rooting. When root formation is slow in formation the next time trial at a higher rate. When leaf curl, leaf spotting occurs, the plants will out grow the problem when new leaves form.

Observations on Foliar Rates

Start with the intermediate foliar rate. If you get good rooting then trial the next plant lot at a lower rate until rooting becomes reduced or slowed. If there is inadequate rooting, with no observed effects, like curls or spots, then use a higher rate. For foliar applications always use water based rooting solutions using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. *Never use solvents, like alcohol, to make the solutions since they may cause plant mortality.*

Tender annuals and perennial plants
(like vegetative geranium, petunia, New Guinea impatiens)

▼ - Lower foliar rate may have reduced root formation
Typical Foliar Rates: 80-500 ppm water soluble IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablet rooting solutions.
▲ Higher rate may cause leaf spotting, leaf curl, aerial roots, side roots.
▲ + Higher rates do not usually cause long range problems and sometimes induce high quality roots earlier.
➜ + Alternatives to foliar methods using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets solutions: Basal Quick Dip at 50-200 ppm IBA or Basal Long Soak, 50-100 ppm IBA for 12-24 hours or Rhizopon AA **#1 and #2** Dry Dip rooting hormones.

Hardy perennials and tender woody plants
(like salvia, rudbeckia, rosemary)

▼ - Lower foliar rate may have reduced root formation
Typical Foliar Rates: 25, 500, 1000 and 1500 ppm water soluble IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablet rooting solutions.
1500 ppm IBA is not usually used.
Above 1000 ppm IBA use Hortus IBA Water Soluble Salts.
▲ Higher rate may cause leaf spotting, leaf curl, aerial roots, side roots.
▲ + Higher rates do not usually cause long range problems and sometimes induce high quality roots earlier.
➜ + Alternatives to foliar methods using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets solutions: Basal Quick Dip at 50-500 ppm IBA or Basal Long Soak at 50-100 ppm IBA for 12-24 hours or Rhizopon AA **#1, #2, #3** Dry Dip rooting hormones.

Woody ornamental plants
(like viburnum, self rooted rose, forsythia)

▼ - Lower foliar rate may have reduced root formation
Typical Foliar Rates: 750, 1000, 1500, 2000 ppm water soluble IBA using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablet rooting solutions.
2000 ppm IBA is not usually used.
Above 1000 ppm IBA use Hortus IBA Water Soluble Salts.
▲ + Higher rates do not usually cause long range problems and sometimes induce high quality roots earlier.
➜ + Alternatives to foliar methods using Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets solutions: Basal Quick Dip at 100-5000 ppm IBA or Basal Long Soak at 50-200 ppm IBA for 12-24 hours or Rhizopon AA **#1, #2, #3** Dry Dip rooting hormones.

Rate conversion:
100 ppm water soluble IBA as Hortus IBA Water Soluble Salts =
2 Rhizopon AA Water Soluble Tablets/liter water

Spray Drip Down Method: How to Use

The Spray Drip Down Method uses the rooting solution one time. There can be no cross contamination using the solution between plant lots. Labor is reduced since the workers who do sticking do not individually apply the rooting solution. Workers who do the sticking do not handle the rooting solutions and do not need PPE. Spraying performed by a trained operator assures that the plant cuttings receive a uniform application of the rooting solutions. Alternate: for cuttings with large overlapping leaves the Total Immerse Method may cover the leaves better than spray.

THE METHOD

Equipment

Use a hand, backpack or power sprayer with mix tanks. These sprayers give uniform flow over a directed area. Do not use overhead boom sprayers; they do not permit full control of the spray application. Do not use proportional solution mixers or booms since they might not give uniform solution quality and distribution.

Sticking

Stick the un-treated cuttings in the media. Sticking can be done one day. The rooting solution can be applied the same day, the following day, or after a weekend. Keep the cuttings hydrated before and after treatment. Separate the plants into solution rate groups; plants with the same rate can be treated at the same time.

Materials

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

Spray application at Bailey Nurseries.
Photo: Bailey Nurseries

Application

Spraying can be done at the end of the day when misting is reduced or the following morning. The stomata in the leaves must be open during the spraying. If the propagation area is hot then wait to do the spraying in cooler early mornings. Spray the rooting solution onto leaves until the leaves are fully covered with the liquid. Drips off

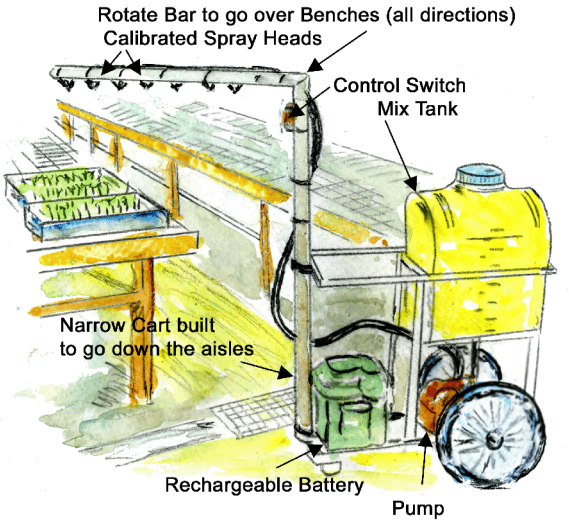
the leaves is an indicator that enough solution has been applied. **Use about one gallon of rooting solution per 175 to 225 square foot of cuttings.**

After Application

After application of the rooting solution wait at until the solution dries, or about 3/4 hour (nominal), before turning on misters or sprayers. Unused rooting solutions in the tank are clean from biological contamination; the solution can be stored at room temperature for several days without losing potency. *Mark the storage container to assure that the contents are properly identified.*

Sprayer used by Bailey Nurseries.
Photo: Bailey Nurseries

Typical backpack sprayer suitable for application



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

Total Immerse Method: How to Use

The Total Immerse Method uses the rooting solution by bulk processing the production lots. Total Immerse can be used for large homogeneous lots of plants, small lots, and plants that are known not to have cause cross contamination. Simple equipment is used for treatment, only as tank and basket. Labor is reduced, the cuttings are treated completely and uniformly. Simple instructions to the crew are needed to obtain optimum results. After treatment the cuttings are stuck. After sticking no further treatment is needed. 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 METHOD

Equipment

Use a solution tank. A dipping basket is useful.

Materials

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

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

Application

Total Immerse the cuttings, using a basket, into the rooting solution for a few seconds.

After Application

Stick the cuttings in media. The cuttings do not have to be stuck immediately after treatment. If the time from dipping to sticking is nominally more then 3/4 hour, the misters can be turned on at any time.

Basal Method: Basics

Using basal methods, rooting hormones are applied to the basal ends of cuttings. Basal methods can be used all year. Two types of products are used, dry dip rooting hormones and rooting solutions.

MODE OF ACTION

Rooting solutions and dry powder rooting hormones are applied to the basal end of the cuttings. The rooting hormones in the products are absorbed into the vascular system where they are stored at the basal end and are used by the plant to induce root formation.

PRODUCTS USED BY BASAL METHODS

Hortus IBA Water Soluble Salts
Rhizopon AA Water Soluble Tablets
Rhizopon AA #1, #2 and 3 dry powder rooting hormones

USE ON MANY TYPES OF PLANT CUTTINGS

Plant cutting types used by basal methods:

- Green-wood.
- Soft-wood.
- Semi-hardwood.
- Hard-wood.

BASAL METHOD SELECTION

For basal application, the Dry Dip and Basal Quick Dip Method are used on a wide range of cutting. The methods can be used on both cuttings taken in the growing season and also dormant winter cuttings. The methods are more labor intensive than the foliar methods. The selection of a method, either dry dip or by solution usually depends upon the particular plant variety. Many plants have successful rooting with either dry dip or solutions methods.

DIFFICULT TO ROOT CUTTINGS

Some growers believe that the use of Dry Dip Rooting Powders or Basal Quick Dip rates at high concentrations will promote the root formation on more difficult to root cuttings. The result is often lack of success even with the higher rates. For difficult to root cuttings the Basal Long Soak Method is often a better choice then the other methods.

Dry Dip Method: How to Use

The Dry Dip Method is used to propagate plants from cuttings from easy to difficult to root. Rhizopon AA rooting powders are pre-mixed at accurate rates. For different rate requirements, from plant lot to lot the powders can be easily switched.

Rhizopon AA rooting powders are color coded to assure the products do not get mixed up:

Rhizopon AA #1 ***(0.1% IBA)*** **is pink color**,
Rhizopon AA #2 ***(0.3% IBA)*** **is green color**
Rhizopon AA #3 ***(0.8% IBA)*** **is white color**.

USE ON MANY TYPES OF PLANT CUTTINGS

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

THE METHOD

Equipment

Rooting powers are taken from the stock container and put into small cups.

Materials

Take enough Rhizopon AA #1, #2 or #3 rooting powders from the stock container for the current needs. For trial concentration use the rate charts.

Application

Prior to treatment, wounding of the basal end may be required for woody plant cuttings. Dip the basal end of the cuttings about 1/2 inch into the dry dip rooting hormone powder. Obtain a uniform coating; tap off excess powder. Roots can be expected to form where the cuttings are covered with the powder. A small amount of powder on the leaves may not affect the quality of the rooting.

After Application

Stick the treated cuttings in media. A dribble hole is useful to allow entry of the cutting into the media without pushing off the rooting powder. After treatment of the cuttings, discard the used powder. Do not return used powders to the stock container.

Rhizopon chrysanthemum trial using Rhizopon AA dry powder rooting hormones. Photo: Rhizopon

Rhizopon pot rose trial using Rhizopon AA dry powder rooting hormones. Photo: Rhizopon

Basal Quick Dip Method: How to Use

The Basal Quick Dip Method is used to propagate plants from cuttings from easy to difficult to root. Several concentrations can be made up. For different rate requirements, from plant lot to lot the solution containers can be easily switched.

USE ON MANY TYPES OF PLANT CUTTINGS

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

THE METHOD

Equipment
Dispense rooting solutions into small cups.

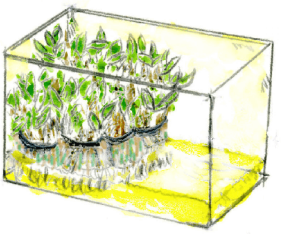
Materials
Make up a rooting solution with either Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. Use the trial rate charts as a starting point. Use as low a concentration as required to achieve good rooting results.

Cutting preparation. Photo: Bailey Nurseries

Application
Wounding of woody cuttings is optional. Herbaceous cuttings are not wounded. Immerse the basal end of the cuttings about 3/4-1 inch into the rooting solution for a few seconds.

After Application
Stick the cuttings after treatment. After treatment of the cuttings, discard the used solution.

Basal Long Soak Method: How to Use



The Basal Long Soak Method is used to propagate plants from cuttings that are difficult to root. Both hard to woody plant cuttings and herbaceous cuttings benefit from the method. The Basal Long Soak Method uses very low solution rates. The method is a better choice than using high rates by the Quick Dip Method rates or high rate dry dip powders.

USE ON HARD TO ROOT PLANT CUTTINGS

In the growing season.	**Leafy cuttings:** annuals, perennials, ornamental and re-forestation plants.
All year.	**Ornamental and re-forestation plants.**
Winter dormant cuttings.	**Ornamental and re-forestation plants.**

THE METHOD

Equipment

Use a tank that allows the bundled cuttings to stay erect. The rooting solution is poured into the tank allowing the basal ends of the cuttings to sit in about an inch of rooting solution.

Materials

Make up a rooting solution with either Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. Use the trial rate charts as a starting point. Use as low a concentration as required to achieve good rooting results.

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

Application

Wounding of woody cuttings is optional. Herbaceous cuttings are not wounded. Immerse the basal end of the cuttings about 3/4-1 inch into the rooting solution for 12 to 24 hours (nominal). Timing is not critical.

After Application

The treated cuttings can be stuck immediately or kept in cold storage until planting. After treatment of the cuttings, discard the used solution.

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

PRUNUS ROOTSTOCKS: SPECIAL APPLICATION

European growers have for over fifty years used the Basal Long Soak to root cuttings of prunus rootstocks including St. Julian (plum and other stone fruit, etc.). In the Autumn 16" cuttings are taken from the stock plant. Basal ends of the cuttings are treated by the Basal Long Soak Method. Typical rates are Hortus IBA Water Soluble Salts at 100 ppm water soluble IBA or Rhizopon AA Water Soluble Tablets at 2 Tablets per liter water. Immerse 12-24 hours. After treatment the cuttings are bundled and wrapped in perforated transparent plastic. The packages are placed into crates which are piled to allow air circulation. The crates are kept in cold storage above freezing, 33-35°F, for the Winter. Ethylene generation is checked regularly as it could be toxic to the cuttings. During cold storage a callus ferrule forms around the lower end of the basal end. In the Spring the cuttings are planted in the open.

Spray Drip Down and Total Immerse Methods: Selected Rates

Rates shown are for Hortus IBA Water Soluble Salts. Use the Conversion Chart to use Rhizopon AA Water Soluble Tablets. Plant cuttings vary in quality. Trial rates shown are from specific lots under the growers particular faculty and environmental controls. Your growing facility and plant lots are different; ***always perform your own trials for your plants and facility.***

RATES FOR CUTTING TYPES	HORTUS IBA WATER SOLUBLE SALTS (ppm IBA)	RHIZOPON AA WATER SOLUBLE TABLETS (tablets/liter water)
Soft perennial cuttings **Annual cuttings**	**50-500**	**1-10**
Herbaceous cuttings **Woody ornamental cuttings**	**500-1500** **750-1500**	**10-20 *** **15-20 ***

* Above 20 Rhizopon AA Water Soluble Tablets per liter, 1000 ppm water soluble IBA, use Hortus IBA Water Soluble Salts.
Rhizopon AA Water Soluble Tablet conversion:
50 ppm IBA = 1 Rhizopon AA Water Soluble Tablet per liter
500 ppm IBA = 10 tablet, 750 ppm = 15 tablet, 1000 ppm = 20 tablet/liter

Typical ANNUAL PLANTS Propagated by the Spray Drip Down and Total Immerse Methods

Pelargonium geranium
- sp. like "Balcon" 50-100 ppm
- zonale 200-300 ppm
- peltatum 300-400 ppm

Impatient New Guinea 15-50 ppm
Fuchsia 15-50 ppm
Petunia sp. 150-200 ppm
- some colors 200-300 ppm

Osteospermum 150-200 ppm,
- also: Rhizopon AA #2 and #3

Verbena 200-300 ppm,
- also: Rhizopon AA #2 and #3

Poinsettia 25-100 ppm

Typical PERENNIAL PLANTS Propagated by the Spray Drip Down and Total Immerse Methods

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

Typical WOODY ORNAMENTAL PLANTS Propagated by the Spray Drip Down and Total Immerse Methods

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

REFERENCES

Rhizopon Rooting Guide. Rhizopon, Hazerswoude, Holland
Yoder Garden Mums and Asters (2008-2009). Yoder Brothers, Barberton OH.
Yoder Handling Un-rooted Perennials (2004). Yoder Brothers, Barberton OH.

Dry Dip Method: Selected Rates

Typical Plants Propagated by the Dry Dip Method

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	Dracaena	#1	Olive	#3
Acanthopanax	#3	Dutchman's Pipe	#1	Orange, sour	#3
African Violet	#1	Elder	#1 or #2	Orixa	#1
Ageratum	#1	Escallonia	#2	Osage Orange	#1
Andromeda	#1	False Arborvitae	#2	Osmanthus	#2
Apple, Malus	#2 or #3	Firethorne	#1 or #2	Pachysandra	#2 or #3
Arborvitae	#2 or #3	Flowering Cherry	#1	Pea Shrub	#1
Arbutus	#3	Flowering Quince	#3	Pear rootstocks	#3
Ardisia	#2	Fontanesia	#1	Pecan	#3
Azalea *var.*	#1, #2 or #3	Forsythia	#1	Penstemon	#1
Barberry	#1	Franklinia	#2	Periwinkle	#2
Bayberry	#1	Fringe Tree	#2	Petunia	#2 or #3
Beauty Bush	#3	Fuchsia	#1	Philodendron	#1
Beauty Berry	#1	Gardenia	#1, #2 or #3	Phlox	#1
Beech	#2	Geranium	#1	Photinia	#3
Begonia	#1	Germander	#2 or #3	Pine *var.*	#2 or #3
Birch	#3	Ginkgo	#2	Poinsettia	#1
Bittersweet	#3	Golden Chain	#2	Poplar	#1
Blackberry	#1	Grape	#3	Prickly Pear Cactus	#1
Bluebeard	#1	Hawthorn	#3	Privet	#3
Blueberry	#1 or #2	Hazelnut	#1 or #2	Raspberry	#1
Bougainvillea	#3	Heath	#3	Retinospora	#3
Boxwood	#3	Heather	#3	Rhododendron *var.*	#3
Broom	#1 or #2	Hemlock	#2 or #3	Rose	#1, #2 or #3
Butterfly Bush	#1	Hibiscus	#2 or #3	Russian Olive	#3
Camellia	#3	Holly, *Japanese*	#2	Sage	#1
Candytuft	#1	Holly, *American*	#3	Sequoia	#2
Carnation	#3	Honeysuckle	#2	Snapdragon	#1
Catalpa	#3	Hydrangea	#2	Snow Berry	#1
Chaste Tree	#3	Jetbead	#1	Sourwood	#3
Chestnut	#3	Juniper *var.*	#2 or #3	Speedwell	#1
Chokeberry	#2 or #3	Kerria	#1	Spiraea	#1
Chrysanthemum	#2	Knotwood	#3	Springscent	#2
Cinquefoil	#2	Laburnocytisus	#1 or #2	Spruce *var.*	#2
Clematis	#2 or #3	Lantana	#1	St. Johnswort	#1
Clerodendron	#1	Laurel	#3	Stevia	#1
Clockvine	#1	Lavender	#2	Stewartia	#1
Coleus	#1	Leucothoe	#2	Sweet Leaf	#1
Cotoneaster	#3	Lilac	#3	Trumpet Creeper	#1
Crab Apple	#2 or #3	Lily Scales	#1 or #2	Tulip Tree	#3
Cape Myrtle	#1	Linden	#1	Umbrella Pine	#3
Crassula	#1	Locust	#3	Verbena	#1
Creeper	#1	Magnolia	#2 or #3	Viburnum	#1
Croton	#1	Manzanita	#3	Waxmyrtle	#1
Cryptomeria	#3	Maple, *Japanese*	#3	Weigela	#1
Currant	#1	Matrimony Vine	#3	Willow	#1
Dahlia	#2	Melastoma	#1	Wintergreen	#2
Daphne	#1 or #2	Mock Orange	#1	Wisteria	#2
Deutzia	#1	Mulberry	#1	Witch Hazel	#2
Dew Berry	#1	Ninebark	#3	Yellow Wood	#2
Dogwood	#3	Norway Spruce	#1	Yew *var.*	#3
Douglas Fir	#3	Oak	#3	Zelkova	#2
Dove Tree	#1	Oleander	#2		

Basal Quick Dip Method: Selected Rates

RATES FOR CUTTING TYPES	HORTUS IBA WATER SOLUBLE SALTS (ppm IBA)	RHIZOPON AA WATER SOLUBLE TABLETS (tablets/liter water)
Annuals	**80-200**	**1-4**
Herbaceous, perennials, tropical hose plants, pot rose., etc. *(For difficult to root perennials consider using the Basal Long Soak Method)*	**150-500** **Sometimes: 500-1500**	**3-10** **10-20**
Softwood	**500-1500**	**10-20**
Hardwood	**500-2000**	**10-20**
Difficult to root hardwood *(For these consider using the Basal Long Soak Method)*	**5000-10,000**	**Use Salts**

Typical Plants Propagated by the Dry Dip Method

Selected plant varieties for the Basal Quick Dip Method are not listed in this book. Many variables effect rate selection.

Some books and articles list specific rates for particular species and varieties. The rates may have been reprinted, from one book, to the next book, to the next book, without the authors confirming the accuracy or getting exact details! Results from one non-reproducible trial should not be taken as the best choice for your need.

Published specific rate charts may not take into account factors such as:

Juvenility of the stock plant.
Time that the cuttings are taken.
Variables in the collection pool at the harvesting time.
Storage and transportation of the cuttings.
Preparation of the stock plant relative to light and fertilization.
Media used.
Conditions in the stock plant area.
Conditions in the production facility.
General environmental factors.

Basal Long Soak Method: Selected Rates

RATES FOR CUTTING TYPES	HORTUS IBA WATER SOLUBLE SALTS (ppm IBA)	RHIZOPON AA WATER SOLUBLE TABLETS (tablets/liter water)
HARD TO ROOT: Annual, perennial and other herbaceous plants	**25-100**	**1/2-2**
HARD TO ROOT: Softwood, hardwood	**50-200**	**1-4**

Typical Plants Propagated by the Basal Long Soak Method

Hardwood and Softwood, Difficult to Root Cuttings

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

Annual, Perennial and Other Herbaceous Plants

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

HIGH RATE QUICK DIP SOLUTIONS & DRY DIP POWDERS

When treated cuttings fail to produce roots, growers often increase the Basal Quick Dip or Dry Dip concentrations. This is not always the best answer. Excess rooting hormones can inhibit of root formation. The basal end of the cutting is a sink point; the place where the rooting hormones are stored until they are used for root formation.

The use of high rate Basal Quick Dip is not always a good method to overcome unsuccessful rooting. A better method may be to use the Basal Long Soak Method at low rates.

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 2-¾". 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.

BAILEY NURSERIES RATES (2009)

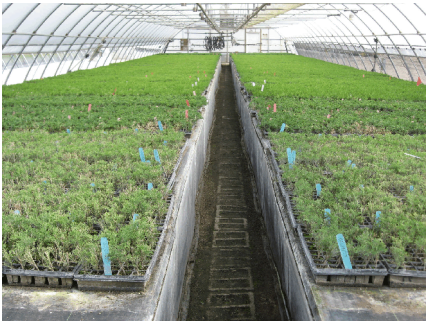
Spray Drip Down Method using Hortus IBA Water Soluble Salts rooting solutions are applied by Hydraulic Sprayers. Woody ornamental plants propagated from leafy cutting in the growing season.

RATES: Most of Bailey's ornamental use a range from 750 to 1000 ppm water soluble IBA using Hortus IBA Water Soluble Salts rooting solutions. Other plants are propagated using a rates from of 375 to 1500 ppm water soluble IBA using Hortus IBA Water Soluble Salts rooting solutions.

Bailey growers always do trials to find low rates that often produce excellent rooting results

Bailey Nurseries Ornamental Plant Production

Photos: Bailey Nurseries



Forestry Applications

Growers of forestry trees, shrub and reclamation plants need vegetative propagation to produce select varieties. It is important for these plants, whether propagated vegetatively or from seed, to have enhanced the root mass. Both vegetative propagation and root mass improvement can be done with rooting hormones.

PROPAGATION FROM CUTTINGS

Growers can propagate many varieties of deciduous trees and plants from cuttings using **basal and foliar methods.** Conifers, like Pseudotsuga (Douglas fir), Chamaecyparis (false cypress), Juniper, and Taxus (yew), can be propagated from winter or late spring cuttings using Rhizopon AA #3 dry powder rooting hormones by the **Dry Dip Method.** Dip the basal end of the cutting into the rooting powder then stick.

Another method is to use the **Long Basal Soak Method**. Soak the basal end of the cuttings 3/4 -1 inch or more into a rooting solution of Rhizopon AA Water Soluble Tablets at 1-4 Tablets per liter or water, or Hortus IBA Water Soluble Salts at 50-200. Allow the basal end of the cuttings to soak 12-24 hours or more. Stick the cuttings immediately or anytime. Dormant cuttings can be treated in late Fall or early Winter. The treated cuttings may be put into plastic bags and stored in cold storage for spring planting.

IMPROVING ROOT MASS

To improve the root mass of plants in the growing season spray the rooting solution onto the leaves until the liquid drips down. It is best to maintain visual control over where we apply the solution. Use a rooting solution of Rhizopon AA Water Soluble Tablets at 1-2 Tablets per liter of water, or Hortus IBA Water Soluble Salts at 50-100 ppm water soluble IBA.

The place, timing and method application should be selected for ease of spraying. Plants must be treated uniformly; a greenhouse or propagation house may be the best place to do the application. The solution should be put into the tank of a hydraulic or other sprayer. Proportional mixers are not suitable since they might not give uniform blending. Boom sprayers may miss some plants and waste solution with over spray.

Application to rooted plants can be done anytime after they form the leaves, and one and two year old plants. Application can be done before transplanting and at the beginning of the growing season. Repeat applications can be made in several week intervals during the active growing season.

PHYSIOLOGY

The action of the solution is to the leaf, not to the soil. Treatment is when the plants are in the growing season. The plants absorb the rooting solution through open stomata in the leaves. The auxin active ingredient moves by mass flow to the basal end where it is stored. The auxin is slow released by the plant for root formation.

AMOUNT OF SOLUTION REQUIRED

Greenhouses and propagation houses have plants closely spaced; application is efficient.

To treat 200 sq. ft.

50 ppm water soluble IBA rooting solutions using Hortus IBA Water Soluble Salts needs 0.25 grams of Salts per liter. At 3.8 liters per gallon: 3.8 x 0.25 = about one gram of Salts.

One gallon can treat 175 to 225 sq. ft.

Using Hortus IBA Water Soluble Salts (@ about $0.30 per gram), to treat 200 sq. ft. the cost is about 30¢

To treat an acre

There are 43,560 sq. ft. per acre. At one gal per 200 sq. ft.: 43,560/200 = 218 gallons. At 50 ppm water soluble IBA you need about 218 grams of Hortus IBA Water Soluble Salts per acre.

Preparing conifer cuttings. Application of Rhizopon rooting hormones by the dry dip method. Boskoop Holland. Photo: Rhizopon

Juniper cuttings.
Photo: Bailey Nurseries

Preparing conifer cuttings. Boskoop Holland.
Photo: Rhizopon

Transplanting

Improve growth of slow to root cuttings, TC plants and bareroot plants

OVERCOMING SLOW ROOT DEVELOPMENT AND FOR TRANSPLANTING ROOTED CUTTINGS

Leafy cuttings in the growing season, which are already treated and planted, are sometimes slow or irregular to root. To stimulate rooting use one or two weekly additional applications of the rooting solutions by the Spray Drip Down Method. Use Hortus IBA Water Soluble Salts at 75-200 ppm water soluble IBA, or Rhizopon AA Water Soluble Tablets at 2-4 Tablets per liter water.

IMPROVING TRANSPLANTING OF TISSUE CULTURE PLANTLETS

When transplanting tissue culture propagated plants they sometimes do not have adequate roots to produce good plants. Since the plantlets do not have working stomata, Rhizopon advises to use the Total Immerse Method to apply Hortus IBA Water Soluble Salts at 100-300 ppm water soluble IBA, or Rhizopon AA Water Soluble Tablets at 2-6 Tablets/liter water. After treatment stick the plantlets. The same rates can be used on the plantlets after the first new leaves appear, and also when they are in an advanced state of development.

TRANSPLANTING BARE ROOT PLANTS

Application of rooting solutions to bare root plant can increase root mass. For example, the old way for floriculture rose growers is to allow one to two years of growth before transplanting rose bushes. Without treatment the rose transplant uses it's energy to rebuild a root system instead of entire plant growth. Treated rose bushes have increased first year flower yield.

One year rose bush roots are shown. The root on the left was un-treated. The root on the right was treated with a Rhizopon rooting solution by basal long soak. The treated bush has more fibrous growth and greater root mass. Photo: Rhizopon

Method

To improve root regeneration, the bare roots are treated by basal soak. Before treating, the roots are not cut back except for damaged or broken roots. The bare roots are immersed in the solution for 10-30 minutes (nominal) in a solution containing Rhizopon AA Water Soluble Tablets at 3-5 Tablets per liter water, or Hortus IBA Water Soluble Salts at 150-250 ppm water soluble IBA. After treatment the bushes are planted immediately or stored for later planting. At planting time the soil temperature should be above 60°F, air temperature above 65°F, and relative humidity at 80%. Warm soil temperature helps the utilization of the solutions.

Auxins and the Pathways for Foliar Application

Plant researchers had long known that plants produce chemicals that cause to divide and become roots. In 1934 Thimann and Went identified IAA *(Indole-3-acetic acid)*, a rooting hormone, now called auxin.

IAA is produced in the leaves of plants and is found in other plant parts. It is unstable and degrades rapidly in the presence of light and heat. More stable than IAA, the bio-simulators IBA *(Indole-3-butyric acid)* and *(Naphthalene acetic acid)* are the commercially used rooting compounds. IBA and NAA are stable and remain active for use by plants over a long time. IBA and NAA are known to induce plant cells to form adventitious roots. Of the three, IBA is the most useful auxin to propagate plants from cuttings.

The way that IAA, IBA and NAA are used by plants to induce root formation is not fully understood. The use of auxin treatments, and the selection of the compounds, in rooting cuttings is not universal since some species react better than others to the treatment.

The natural auxin, IAA, is bio-synthesized in fully developed and young leaves. It is also found in seeds. IAA is transported through the plant from cell to cell in various parts of the plant, vascular cambium, pro-cambial strands and perhaps the epidermal cells.

Relative to root formation, some effects of the auxins have been observed:

- cell enlargement that likely increases root and stem length
- cell division that assists in root formation
- root initiation by inducing roots on stems and sometimes leaves
- apical dominance that sometimes effects the stem and leaf growth when using foliar applied auxins
- tropic responses (bending) that is sometimes noticed on tender leaves when using foliar applied auxins.

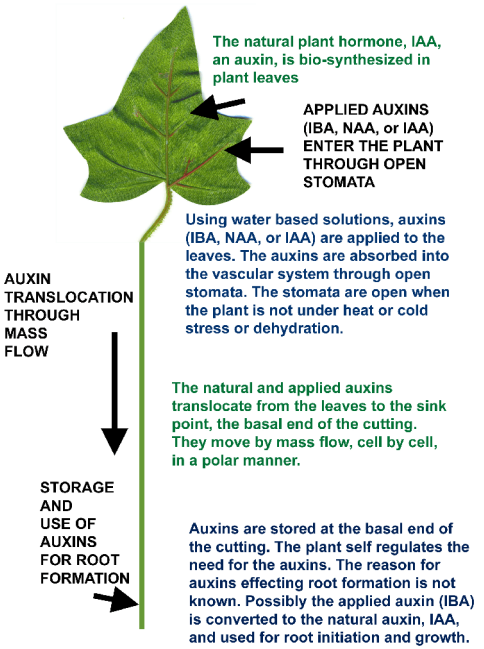
Auxins have other effects on plants:

- leaf senescence, delay of leaf drop
- leaf and fruit abscission, leaf and fruit drop
- fruit setting and growth
- promotes flowering in some plants like bromeliads
- growth of flower parts
- In some cases, the effect of excess auxin is to inhibit growth. (1)

To induce root formation, early investigators and growers until today have applied the auxins to the basal end of the cuttings.

Dry compounds: Dry powder auxin compounds and solutions containing auxin were found to be useful. The auxins are blended with a carrier, usually talcum powder. Early users also mixed the auxins with powdered charcoal.
Liquid compounds: Common forms of the auxins are soluble in active solvents like alcohol. The solutions made with the auxins were first used in low concentration basal soaks.
Lanolin compounds: Not used today, auxin is mixed with lanolin, a natural material produced obtained from wool processing.
The compound was applied to the basal end. In rare cases the lanolin compounds was applied to plant leaves. (8)

Using rooting solutions at low concentrations, early literature describes the basal long soak method. The basal end of the cuttings are immersed in the solution, at a few ppm auxin, for a few hours to several days. The method is successful on many kinds of plants. It has been used on soft herbaceous to woody ornamental plants. Later, the basal quick dip method was developed. The basal end of the cuttings are immersed in the auxin solution for a few seconds. The method uses auxin rates much higher than the basal long soak method. Alcohol as the solvent is need to make solutions of the auxins. Early users found alcohol to cause phytoxicity to plant cells and case mortality to the cuttings. The water soluble salts of the auxins was not as well adopted. Therefore, the auxin solutions were used at low rates to allow use of low concentrations of the alcohol.



ROUTE OF FOLIAR APPLIED ROOTING SOLUTIONS THAT CONTAIN AUXIN FOR USE IN ROOT FORMATION

EARLY OBSERVATION: leaf contribution to root formation

In 1946, van Overbeek observed that the action of the natural plant rooting hormone in the leaves of plants is essential for plant cuttings to form roots at the basal ends. The rooting hormones are transported from the leaves to the basal end. The basal end is a wound sink point of cuttings.(2)

Figure 1
Graphic: Hortus USA

Dutch Rhizopon researchers identified the stomata of leaves as a place to induce water soluble auxins into the plant's vascular system to stimulate root formation. In 1985 the Rhizopon techniques were introduced to growers. The methods are to spray the solution onto the leaves, the spray drip down method, or to totally dip the cuttings into the solution, the total immerse method. Figure 1

FREE IAA PRODUCTION

The natural plant rooting hormone (auxin), IAA, is produced during the development of leaves. Hydrathodes are the water secreting glands which develop in the leaf tips and later in the leaf lobes. As the leaves develop, the hydrathodes are the primary sites of free auxin production. Trochomes, the epidermal hair structure, and mesophyll, the storage cells between the epidermal layers of the leaf, are secondary sites. Figure 2 **Free auxin production progresses from the elongating tip and continues downward along the expanding leaf blade margins**. (3)

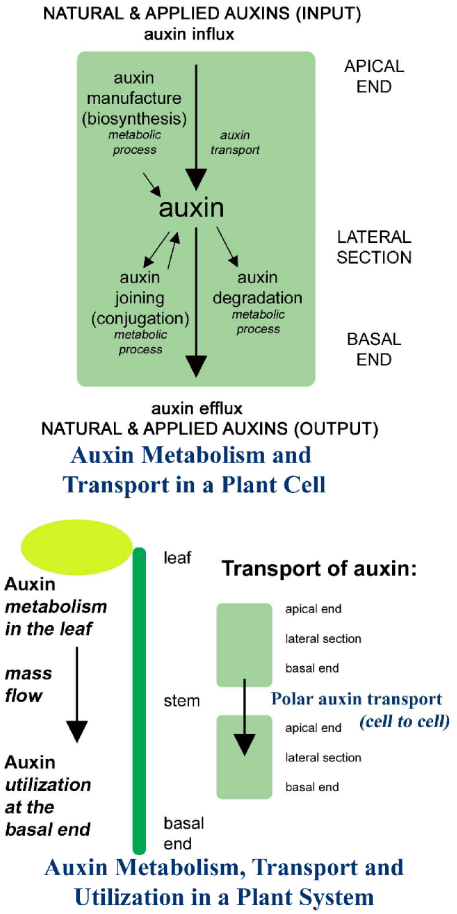


Figure 2
Graphic: Hortus USA

USEFUL AUXINS FOR FOLIAR APPLICATIONS

Both IBA and NAA have been found useful as single component applied auxins Of the three auxins, IBA has been most the most used for foliar application. Eigenraam at Rhizopon found that the combination of IAA and NAA, and IBA and NAA are effective on pot rose propagation.

CARRIER

As the natural fluid in the plant structure, water was selected by Rhizopon as the carrier for the plant rooting hormones for foliar applications of rooting hormone solutions. While alcohol is another solvent for rooting hormone compounds it was not selected. Alcohol can be phyto-toxic to plant tissues since it will dehydrate plant cells and cause the mortality; this phenomenon is commonly called 'alcohol burns'.

INDUCTION POINT: THE STOMATA

Stomata are the minute openings in leaves that allow the flow of gases and fluids into the plant. The Stomata are protected, each by two guard cells. These cells cause the stomata to be open during normal room temperature. The stomata close when the plant is under stress, such as from heat or cold. Stomatal closure limits the water loss from the leaf area and to limit the size of the leaf area such as when curling. Auxins in a rooting solution, applied to open stomata, are taken into the plant's vascular system. Air spaces under the guard cells and stomata serve to store the induced rooting solution, to be later translocated through the vascular system . Figure 3

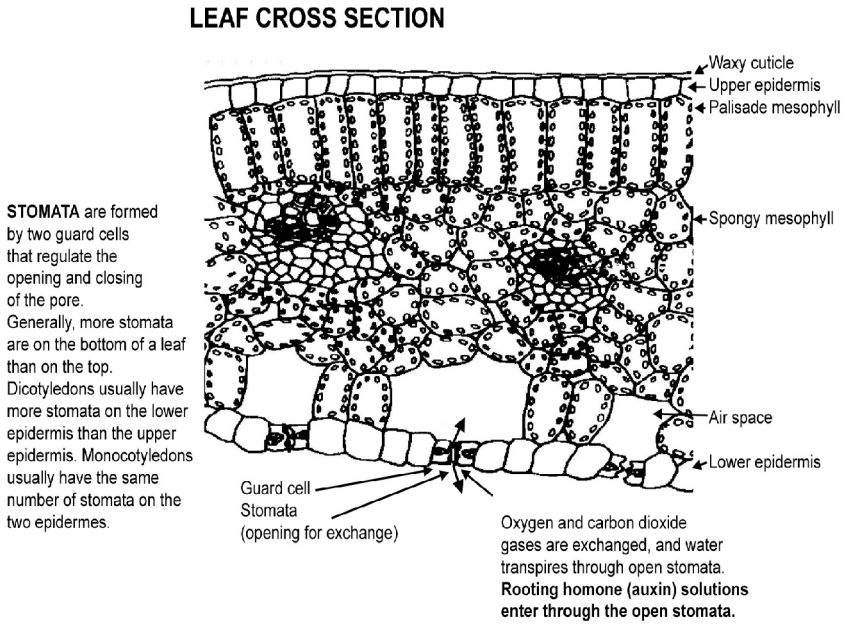
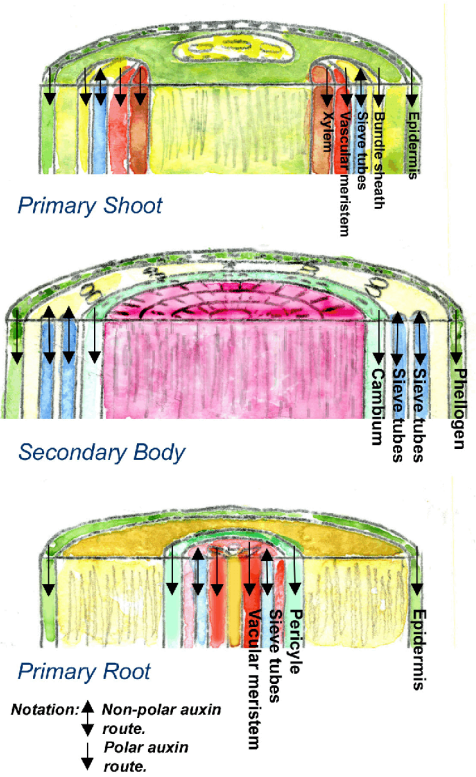


Figure 3
Graphic: Hortus USA

TRANSLOCATION: MASS FLOW

The auxins, in solution, are translocated rapidly by mass flow in the mature phloem. Auxin transport is strongly polar through cells and tissues. They are transported cell to cell, from the leaf source downward toward the basal end of plant cuttings. The speed of motion, a few centimeters per hour, is regulated by the plant. The flow is carrier dependent. For IBA and NAA the actual time of travel is not critical since they are remain active a long time. The plant self regulates the use of the auxins. as it is needed, for root formation and other plant growth functions.

Studies of auxin transport have shown the velocity of IAA at 7.5 *mm/hour*, NAA at 6.7 *mm/hour*, and IBA at 3.2 *mm/hour*. Using labeled auxins, IBA was reported the travel in polar transport; most of the IBA remained in the bases of the cuttings. (6) Figure 4



Free Auxin Transport in Plant Shoot, Body and Primary Root

Figure 4
Graphic: Hortus USA

Two physiologically distinct, and spatially separated pathways, function to transport auxins over long distances through plants.

Polar transport (one way transport)

In the non-polar route, auxin is translocated rapidly by mass flow and other metabolites in the mature phloem. **Transport is downward** from immature tissues close to the shoot apex toward the root tips. In solution, the auxin that is loaded into a mature phloem is translocated passively in the phloem sap to sink organs and tissues at the basal end where it is released. (4) Figure 4

In the non-polar route free auxin moves inside

- **the primary shoot** through the epidermis, bundle sheath, vascular meristem, and the xylem.
- **the secondary body** through the phellogen, and the cambium.
- **the primary root** through the epidermis, pericycle, and vascular meristem.

Non polar transport (two way transport)

In the non-polar route auxin moves up and down the sieve tubes. (5)

PLANT UTILIZATION OF IBA & IAA TO INDUCE ROOT FORMATION: IBA CONVERSION TO IAA

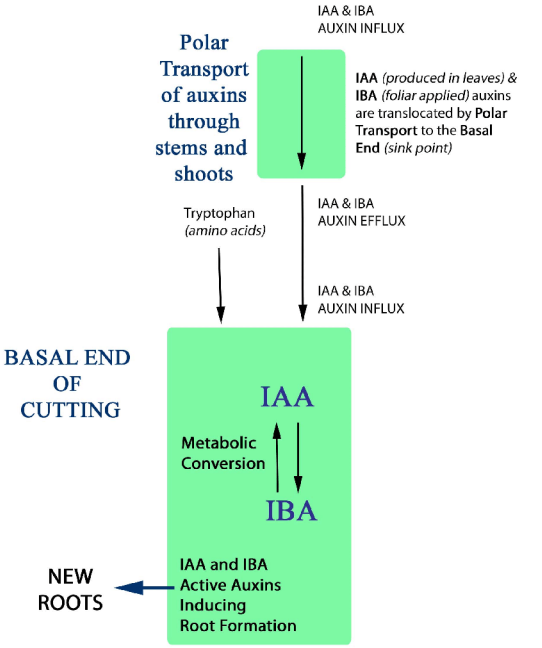
In some plant cuttings, IBA was shown to be slowly metabolized by the plant to IAA. The IAA and IBA co-factors serve as a time release growth regulator. IBA was found to be an endogenous, synthesized, constituent of various plants. Studies of auxin transport showed IAA was transported faster than IBA. Like IAA, IBA was transported mostly in a “basipetal direction”, polar transport. It has been claimed that easy to root, as opposed to difficult to root cultivars, have the ability to hydrolyze auxin conjugates during growth to time release free auxin which may induce and boost root initiation. This theory is supported by reports on increased level of free auxin in the bases of cuttings prior to rooting. Easy to root cultivars are also able to convert IBA to IAA which accumulated in the cutting bases. The higher rooting promotion of IBA was also ascribed to the fact that its level remained elevated longer than that of IAA even though IBA was metabolized in the tissue. (6) The metabolism of IBA was observed in hardwood cuttings of grapevine and olive. It was found that both plant species converted IBA to IAA as confirmed by chromatography. (7) Figure 5

TIMING

Auxin solutions enter the stomata rapidly and are captured in the leaves and stems of the plants. The solutions are able to freely move down the leaves and stems toward the rooting site sink point. The speed of travel of the solution is influenced by plant variety, hydration and irradiance. Once the induced solution is in the plant system there is no critical amount of time for the auxin to translocate to the rooting site. After auxins in the plant system operations, such as misting of leaves, can resume.

DISCUSSION

Water based rooting solutions, with auxin compounds such as IBA, can be applied to the leaves of plant cuttings. The solution enters the vascular system of the plant through open stomata. Auxins translocate polarly through the stems to the basal end of the cutting. IBA can be converted by the plant to IAA, by slow bio-transformation, and utilized by the cutting to make new roots at the basal end.



Graphic: Hortus USA
Simplified IAA and IBA metabolism links suggested by: Epstein, Ludwig-Wuller, 1993. Indole-3-butyric acid in plants occurence, synthesis, metabolism, and transport. Physiologia Plantarum 88:382-389

BASAL END OF CUTTING, STORAGE POINT OF AUXINS: Metabolic conversion of IAA < > IBA available to be utilized by plant tissues for root formation

Figure 5

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A Tribute to Kenneth Vivian Thimann

The first part of the 20th century was the golden age of exploration of how plants function. Beginning his studies early in the century, Kenneth Thimann was curious as to how plants grow. He did experiments with some of the great scientists of the time. His work on plant hormones, a form of plant growth regulators, led to practical applications of the science used today.

Kenneth Vivian Thimann was born in England, on August 5, 1904. Thimann studied chemistry at Imperial College in London, where he received a Ph.D. in biochemistry in 1928. He taught two years at King's College for Women in London. After in the US, he was on the faculty of the California Institute of Technology in Pasadena (1930–35), he was a professor at Harvard University (1935–65), and the University of California at Santa Cruz from 1965. He became a U.S. citizen in 1941. His Ph.D. thesis concerned contributions of individual amino acid residues to the ionization of proteins. Later he worked with and published papers with the plant scientists Herman Dolk, James Bonner and Folke Skoog. Thimann began his search for the growth hormone with Dolk in the early 1930s at the California Institute of Technology.

By 1934, Frits Went had shown that a substance, later named auxin, produced in minute amounts by seedling tips and causes the cells below to elongate. This substance, the first hormone recognized in plants, was also made by the fungus Rhizopus suinus. Thimann deduced that the active compound might be indole-3-acetic acid (IAA). He demonstrated that synthetic IAA had the same biological and chemical properties as the fungal auxin. Went, Skoog, and Thimann showed that IAA caused cell elongation, enhanced formation of roots on cuttings, and inhibited lateral buds. Thimann and his fellow plant scientists determined the features of the IAA molecule that were responsible for its auxin activity. Synthetic growth regulators developed as a result of this line of work included the weed killer 2,4-D and its chemical relatives.

Thimann wrote over 300 research papers and eight books. Publications of his research include The Natural Plant Hormones (1972), Hormones in Living Plants (1977), and Senescence in Plants (1980).

Kenneth Thimann died on January 15, 1997

Hortus USA Corp.

HISTORY OF HORTUS USA

Hortus USA Corp., headquartered in New York City, was founded in 1989 by Joel Kroin, it's President. The company associated with Rhizopon b.v., of Holland, to import their plant rooting products into the Americas, and to register them with the US EPA. The two companies share research and technical support.

Hortus USA sells and services not only the Rhizopon products but also their own products produced by Rhizopon. They continue to introduce new methods for the varied needs of nursery and greenhouse growers. Hortus USA has introduced American growers to cost effective products using Dutch labor saving plant propagation techniques. Rhizopon AA dry powder rooting hormones and Rhizopon AA tablets used to make rooting solutions were the first products sold by Hortus USA. To meet the needs of American growers, Hortus USA developed Hortus IBA Water Soluble Salts, a fully water soluble IBA containing product.

OPERATIONS

Hortus USA's products are produced in Holland by Rhizopon in their state of the art manufacturing facility. All production lots are quality control tested by an independent E. C. registered laboratory. Hortus USA distributes their products from the St. Louis warehouse of Phytotronics, their master distributor. Hortus USA provides technical support and also through their professional service representatives at Phytotronics.

PRODUCTS

Hortus USA products are end-use plant growth regulator rooting hormones known as auxins. Plant growers use these products to clonally propagate new plants from cuttings. The US EPA registered products contain the active ingredient indole-3-butyric acid (IBA), the most used rooting hormone. The original Rhizopon products are Rhizopon AA #1, #2, and #3 dry powder rooting hormones, and Rhizopon AA Water Soluble Tablets. Hortus IBA Water Soluble Salts are also available. In plant propagation, the Salts replace technical IBA and K-IBA.

The Rhizopon AA dry powder rooting hormones are used by the basal dry dip method. The Rhizopon AA Water Soluble Tablets and Hortus IBA Water Soluble Salts, dissolved in ordinary water, are used to make plant rooting solutions. To make solutions the Tablets are measured by counting tablets per unit of water; the Salts powder is measured by weight per unit of water. The rooting solutions are applied to plant cuttings by basal and foliar methods.