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On the Development of Foliar Applied Rooting Solutions

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To propagate plants from cuttings, Kees Eigenraam told me about the 'foliar' (leaf) application of rooting solutions made with Rhizopon products. That was in 1989 when I came to know Kees. Our introduction was associated with my company, Hortus USA, importing his Dutch Rhizopon plant rooting products into the US.

In those pre-Goggle Scholar days, I did extensive book and journal reading about plant propagation; nowhere could I find reference to 'foliar' use. Before growers knew foliar methods, plant propagation from cuttings using rooting hormones was limited to basal methods. At the time, few growers outside Kees' Dutch and European customers knew of foliar methods. While he had written basic information, mostly his local growers had seen them.

Foliar application of rooting solutions has a short history. The earliest extensive study was Dr. Frederick Davies' histological and physiological research comparing root formation in juvenile and mature cuttings (1978). Dr. Davies found foliar application of water base IBA rooting solutions to be effective to induce roots.

Kees developed the first commercial foliar methods in 1985. At the time, Kees did not know the research by Dr. Davies. The first users were Dutch growers to propagate chrysanthemums from cuttings.

Lacking other names and basic information, I termed the '**Spray Drip Down Method'** and the '**Total Immerse Method'**. Over the years Kees and I improved and documented the methods. Now, growers worldwide use the methods to propagate many types of plants from cuttings. The methods use water base IBA rooting solutions. IBA, Indole-3-butyric acid, is the most useful natural rooting hormone. For plants suitable to be propagated from cuttings, growers apply the solutions to leafy cuttings of annual, perennial, and woody plants in the active growing state. Compared with other propagation methods, foliar methods have improved rooting quality, reduced misses, low labor cost, and low rate material savings.

The Spray Drip Down Method is used by **annual plant growers** such as Dummen's Red Fox rooting stations and Yoder Chrysanthemums, **perennial plant growers** such as Aris Green Leaf Plants and Keepsake Plants, and **woody plant growers** such as Bailey Nurseries. The Total Immerse Method is used when **tissue culture plantlet transplanting** at the greenhouse stage. Total Immerse is also used on large homogenous crops such as hedera (ivy) and pot roses.

I know of five foliar and basal methods to propagate plants from cutting. I do not advocate use of foliar methods all the time. Depending upon the plant variety and

season, basal methods are sometimes better. Some plant varieties, such as selected cultivars of chrysanthemums, are propagated by both foliar and basal methods in the same facility in parallel.

Basal Methods: three methods are used to apply rooting hormones to the basal end of cuttings. The methods are used all year, on leafy and leafless cuttings, in the active growing and dormant states. The Basal Dry Dip Method use rooting hormone powders, and the Basal Quick Dip and Basal Long Soak Methods use rooting solutions.

Foliar Methods: two methods are used to apply rooting hormones to the leaves of cuttings taken in the active growing state. The methods are not used on leafless or dormant cuttings. The Spray Drip Down and Total Immerse Methods use water base IBA rooting solutions.

Basic foliar practice

Growers take leafy cuttings from stock plants in the active growing state since there must be internal fluid flow. Dormant cuttings are not used since there is limited, if any, fluid flow. Leafless cutting have no ‘leaf’ entry points. A water base IBA solution is applied to the leaves. The solution enters the plant’s vascular system through open pores in leaves through stomata. Stomata are open in a temperature range from about 60-90°F (15-33°C), and when the cuttings are well hydrated before treatment. The IBA translocates through the plant's vascular system, to the basal end of the cuttings where it helps to initiate roots.

Scientific studies relating to foliar application

Efficacy

Dr. Davies studies demonstrated the efficacy of foliar application of water base IBA rooting solutions to induce rooting.

Substances used

The natural substances IAA and IBA induce root formation. IAA has been found to be produced in leaves, apparently interacting with other plant substances to produce IBA. IAA is unstable in solution. Stable, water base IBA solutions are suitable to apply by foliar application.

Carrier needed

Water is the natural fluid in plants. Special formulations of IBA can be made into water base rooting solutions. Water base IBA solutions are suitable to apply by foliar methods. As produced, IBA is water insoluble but soluble in alcohol. The alcohol base solutions must not be used by foliar methods. Alcohol can cause the cutting fatality called ‘alcohol burn’.

Entry point of the solution

The entry point of applied IBA into the plant is though stomata. Many studies found stomata to be on all parts of the plant. Their function is to regulate interchange of fluids and gasses between the plant and the environment. The most numerous stomata are on leaf surfaces. On some plants the stomata are

more numerous on the bottom of the leaves. The stomata have two parts, the internal pore and the surrounding guard cells. The guard cells regulate the size of the pores. For foliar application of rooting solutions to work successfully the pores must be open. Studies show stomata are open when cuttings are well hydrated and when temperatures and other factors are suitable for translocation of fluids and air. Stomata close when cuttings are wilted.

Solution movement within the plant

Under the stomata are air spaces which can take in fluids such as water base IBA solutions. Solution absorption is caused by pressure differentials between the liquid outside the leaf and the air space under the surface. After the applied IBA solution enters the leaves, it flows to vascular bundles. The bundles facilitate translocation of fluids through the plant. Along with leaf produced IAA, the applied and natural IBA is polar, one way, translocated to the basal end of the cuttings. At the basal end the plant is able to self-regulate excesses of IBA. The excess translocates, by the non-polar, two way, route, from the basal end to other parts of the plant. Some excess may return to the leaves. If so, the leaves of tender cuttings may exhibit distortions. The visible effect indicates to growers that the applied IBA rate was too high. In that case growers should trial at lower rates. Practice has shown, despite initial leaf indicators, the new leaves usually form normally.

Foliar Methods

The Spray Drip Down Method

The Spray Drip Down Method can be used on many small production lots at one time.

Growers first stick the cuttings into media. No PPE is required to stick untreated cuttings; thin gloves may be used solely for sanitary purposes. It is necessary for grower to use a water base IBA solution such made with Hortus IBA Water Soluble Salts or Rhizopon AA Water Soluble Tablets. A sprayer is selected for the best use in the facility. The solution is sprayed onto the leaves of the cuttings until there is a drip down. The drips are a visual indicator that an adequate amount of solution has been applied. Growers should try to treat both the top and bottom of cuttings. An excess application is best. The solution is used one time, as such there is no biological cross contamination between production lots. The typical solution use is about 200 sq/ft per gallon (10 sq/m per liter). Misters can be turned on after about 30-45 minutes or until the solution dries on the leaves.

The Total Immerse Method

The Total Immerse Method can be used for large homogeneous plant lots that are clean and disease free. Large leaf cuttings benefit by having both sides of the leaves treated at one time. The Method requires little setup and can be used on large or small production lots.

A simple tub and strainer basket are used to treat the cuttings. Growers use a water base IBA solution as above. Cuttings are dipped into the solution until the leaves are completely covered with liquid, about five seconds. When used to treat tissue culture plantlets, growers must take care not over fill the basket, thereby avoiding cutting breakage. Long immersion is not recommended to avoid adverse

reactions. After dipping, growers stick the cuttings into media. Since biological materials from dipped cuttings are dragged into the solution, it is best to dispose the solution between different production lots. If treating a uniform crop, it is necessary to dispose the solution after the end of the work day.

Solutions used by foliar methods

The US EPA prohibits un-registered or technical grade IBA products to be used by growers for plant growing. Two US EPA registered products are allowed to be used to make water base IBA rooting solutions and are labeled for use by foliar application: Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets (both distributed by Phytotronics, phytotronics.com).

IBA can be made into solutions in two ways. Specially formulated IBA can be dissolved in water to make rooting solutions. IBA ‘as produced’ is water insoluble; it can be dissolved in active solvents like alcohol. If applied to the leaves of cuttings, alcohol rapidly evaporates and dehydrates plant tissue causing the fatality `alcohol burns'. In my studies cuttings with solutions containing with as little as 5% alcohol content, there was cutting death within the day of foliar application.

When using foliar methods, I do not recommend use of wetting agents in solutions made using Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets. Trials showed there is no difference when using or not using the agents.

I find some growers prefer to measure and mix solutions rather than dry measure the Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets. Using the required number of grams or tablets, a concentrate solution can be made. The required portion of the concentrate is put in the production tank. Water is added to bring to the required volume. Hortus IBA Water Soluble Salts solutions can be made to over 80,000 ppm IBA using water.

Unless otherwise specified, thin waterproof gloves are adequate for handling water base rooting solutions.

Water base IBA rooting solution products are used by both basal and foliar methods. These solutions replace any pre-mixed rooting solutions when used at the same IBA rate. In growing facilities where both basal and foliar methods are used, this eliminates the need to inventory different rooting solution products.

I have been told some growers have wanted to make rooting solutions using dry dip rooting hormone powders. The powders can not be made into rooting solutions, they are insoluble in water.

Temperature of the solution and cuttings

I have wanted to know application temperature requirements. Growers might do propagation in cold greenhouses or when cuttings are taken from coolers. Based upon my research, the standard foliar application temperature range for cuttings and solutions is about 60-90°F (15-33°C). In that temperature range, stomata are open.

Time between sticking and spraying

I did trials to determine the effect of time between sticking and treatment by the Spray Drip Down Method. Dr. Davies' studies indicated that there was a variation in rooting after several days between stick and treat. My trials determined, it is best to treat the same day as sticking. For PPE purposes, it is advantageous for the treatment person to do spraying at the end of the work day when other production workers are not in the greenhouse. In hot climates, where daytime temperatures are high, spraying is sometimes done early in the morning after sticking, when temperatures are lower.

Hydration and misting

I advise the growers to well hydrate the cuttings when using foliar methods. IBA in the rooting solution enters the leaf within a few minutes after application through open pores in stomata. Stomata are open when hydrated and closed when water deficient. Wilted cuttings have closed stomata, therefore the cuttings must be re-hydrated before treatment. By the Spray Drip Down Method, mist systems must be turned off before treatment to avoid diluting the rooting solution and restored about 30-45 minutes after treatment.

Keeping solutions

My research has shown, it is best not to keep unused solutions for more than several weeks. Unknown biological substances in the make-up water, such as from untreated pond water, wells, or city water, may cause the IBA to degrade. The keeping time of the solution can't be recommended.

The Total Immerse Method requires sticking the cutting into the solution. These cuttings bringing into the solution biological substances which can cause cross contamination between production lots. It is important to dispose the solution after each mixed lot. When using the solution on a homogenous lot requires disposal at the end of the work day.

The Spray Drip Down Method uses the solution one time. Solutions can be kept until used up, however, it is best not to keep the solutions a very long time.

Foliar rates

The same rates are used by the Spray Drip Down and Total Immerse Methods.

Annual plant cuttings

Some tender plant varieties and juvenile cuttings are treated at rates 80-100 ppm IBA. The normal trial range is from 80-200 ppm IBA. If resultant leaf distortions are evident, the rates are to be adjusted downward.

Perennial and woody plant cuttings

Perennial and woody plant cuttings have similar rates. The selected trial rates are 500, 1000 and 1500 ppm IBA. Rates above 1500 ppm IBA are rarely needed except for some mature cuttings. Rates below 500 ppm IBA are sometimes needed for juvenile tender perennial cuttings.

Tissue culture plantlets

When transplanting tissue culture plantlets at the third to fifth (green house)

stages, the Total Immerse Method can be used with Rhizopon AA Water Soluble Tablets at 1-3 tablets per liter water. For blueberry two Rhizopon AA Water Soluble Tablets per liter water are used.

Transplanting divisions

The Spray Drip Down Method is used when transplanting decorative grass divisions. Rates are similar to those used for annual cuttings.

Juvenile cuttings require lower rates than mature cuttings. Growers generally know which of their cuttings are seasonally easy or hard to root and adjust their rates.

From my experience, there is no relationship between the Basal Quick Dip Method rates and foliar rates. The Basal Quick Dip Method rates are usually too high for foliar use.

Cuttings

The rules for taking of annual, perennial and woody plant cuttings are simple: take leafy cuttings in the active growing state. It is always best to use cuttings-from-cuttings when possible. It is important not to take dormant or leafless cuttings, these are propagated by basal methods.

There are other cutting considerations such as not to use cuttings having nodes or buds at the basal end.

Do not cut leaf tips. Some growers cut the tips of large leaf cuttings to obtain more cuttings in a propagation tray. It is not good to cut the tips. The cut causes a wound that is open to infection. Wounds create ‘sinks’; cuttings to use valuable resources to heal the leaf, rather than induce root formation at the basal end. Plants naturally produce root inducing substances in leaves even after cuttings are taken. Cutting tips takes away the rooting boost from what naturally would have been produced.

Secondary and transplant applications

Secondary Spray Drip Down Method foliar application can be used on leafy cuttings in the active growing state that were first treated by any method. The application levels crops and helps to improve root formation on slow-to-root cuttings. Applications can be done weekly or as required. Rates are similar those used for first foliar application for that type of cutting.

One of the major ways to use the Spray Drip Down Method is to treat divisions and young rooted cutting transplants. Growers of ornamental grasses use the Method on transplant divisions at rates as if they were annual cuttings.

Labor savings, quality control, and material cost

Foliar methods have low labor cost, with better control, compared with basal methods; it is faster to stick cuttings when foliar batch treating. There are no `misses' as may happen with individual treat-stick basal methods. Foliar methods, at low rates, have lower material cost than high rate basal methods.

Trials are necessary

Before I recommend conversion of production to foliar application, I advise growers that trials are essential. Growers should do trials on small lots keeping accurate records of methods, using a range of rates, considering the time of the year that propagation is being done, and the varieties. The review of results should also consider the facility advantages, and labor and setup costs for each method.

Hybrid system

In the same growing facility, a hybrid system with both basal and foliar methods is often used at the same time on cuttings propagated in the active growing state. Selection of methods and rates depend upon the species and cultivars.

Overcome questions to use of foliar methods

When I introduce foliar methods, I can imagine what the grower is thinking.

"I didn't learn about it in school, so how good can it be?"
"The boss wants to get the work out so I don't want to try new methods."
"The old propagator did it by the current way and it seems to work.."
"I don't care about the cost."
"I get work out, cuttings look good enough, why try to make them better?"

There are simple answers to questions about 'new' foliar propagation methods.

- All foliar bulk treated cuttings are uniformly treated. The **cuttings don't have basal treatment `misses'.**
- Foliar methods use **about 1/3rd the labor** compared with individual treated basal methods.
- Foliar methods have **low material cost** due to the use of low rates.
- Between production lots, the Spray Drip Down Method **can't cross contaminate diseases and pathogens;** solutions are used once.
- The Spray Drip Down Method's well trained treatment person is the only worker needing PPE. Not handling chemicals, **other workers do not need PPE**. Also, Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets have zero hour REI.
- **What was learned in school may be out dated**. The latest Eight Edition of the text book Plant Propagation Principles and Practices, ed. by Dr. Frederick Davies and Dr. Robert Geneve, discusses foliar methods.
- The number of growers using foliar methods has rapidly increased as they bring their **knowledge of foliar method success** when changing jobs.
- **For persons responsible for controlling cost, foliar methods can save money, improve quality, save time, and reduce labor, when propagating plants from cuttings.**

Summary

Foliar methods are easy to understand and use:

- Growers select cuttings from most plants that are propagated from cuttings using rooting hormones.
- Growers can propagate annual, perennial, and woody plants from cuttings.
- Leafy cuttings are used.
- Cuttings are to be in the active growing state.
- Dormant and leafless cuttings are not used.
- Water base IBA rooting solutions are used
- Cuttings are to be well hydrated before and after treatment.
- Application is to be made at temperatures from about 60-90°F.

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