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Propagate Plants from Cuttings Using Dry-Dip Rooting Powders and Water-Based Rooting Solutions©

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INTRODUCTION

Since early times plant growers knew that plants naturally produce new roots when propagating from cuttings. L.H. Bailey's 1896 *The Nursery Book* listed hundreds of plants that can be propagated by natural methods. By the 1930s scientists identified the natural plant growth regulator, produced in leaves that enhance root formation and other functions. Once they identified this regulator, the scientists synthesized other compounds better than the natural one. They called the rooting hormones "auxins." The auxins were found useful to induce new roots when applied to plants as dry-dip rooting hormone powders and rooting solutions.

Plants will try to make new roots at a wound, such as a basal cut. Logically, to propagate a plant from cuttings, an application of the rooting hormone to the basal end is a good method. In fact, the plant produces its own rooting hormone in the leaf and translocates it, in an aqueous carrier, to the rooting site. Applied through the stomata, minute openings in the leaf, the plant can take up water-based rooting hormone solutions. The plant can move applied and natural rooting hormones through its cells to the rooting site to induce root formation.

HOW PLANT ROOTING HORMONES WORK

Plant researchers had long known that plants produce chemicals that cause dormant and actively growing cells to become roots. In 1934 Thimann and Went discovered that plants naturally produce the rooting promoting substance indole-3-acetic (IAA). The IAA decays in the presence of light and heat. They found auxin "bio-simulators" of IAA that are more stable including indole-3-butyric acid (IBA) and naphthalene acetic acid (NAA). These bio-simulators are not as sensitive to light and heat. To this day scientists do not know how auxins induce root cell division and root formation from dormant root cells. In 1939 Dutch Rhizopon researchers developed auxin products and methods to apply them to plant cuttings in order to induce root formation at the basal end.

In 1946 van Overbeek found 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. These hormones are transported from the leaves to the basal end which is a wound sink point. He and other scientists later found that leaf-applied rooting hormones free flow from apical ends to the basal ends by mass flow in the mature phloem. The action is a few centimeters per hour. The applied hormones stimulate root formation. Leafy plant cuttings can absorb rooting hormones applied to the leaves and enter through the stomata. Cuttings can be treated by totally immersing the leaves and stems in a rooting solution then stick them in media. Another way is to stick the cuttings in media then spray the rooting solutions onto the leaves until the liquid drips down.

METHODS OF ROOTING HORMONE APPLICATION

Table 1. Rooting hormone application methods.

Basal application	Dry-dip method	Use a dry-dip rooting hormone powder: Dip basal end in rooting powder, then plant.
	Basal quick dip method	Use a rooting solution: Dip basal end in rooting solution, then plant.
	Basal long soak method	Use a water-based rooting solution: Dip basal end of cuttings in rooting solution about 12 h, then plant.
Leaf application	Spray drip down method	Use a water-based rooting solution: Plant, then spray leaves of cuttings with rooting solution until the solution drips down.
	Total immerse method	Use a water-based rooting solution: Totally immerse cuttings in rooting solution, then plant.

Table 2. Cutting type used by different application methods.

The type of cuttings used by different methods of application	Dry-dip method	Spray-drip down	Basal quick dip	Total-immerse method	Basal long soak
Leafy cuttings: either ornamental plants or herbaceous plants, in the growing season	T*	T	T	T	T
Leafless cuttings: either ornamental plants or herbaceous plants, all year, winter cuttings	T		T		T
Hard-to-root cuttings	T		T		T

*Notes that method is used.

PLANT ROOTING PRODUCTS

Plant roots are induced to be formed by plant rooting hormones.

- Indole-3-acetic acid (IAA) is the natural hormone produced by plants in leaves during photosynthesis. It is not stable in light and heat and rapidly loses effectiveness.
- Indole-3-butyric acid (IBA) and naphthalene acetic acid (NAA) are stable bio-simulators of IAA.

Indole-3-butyric acid is the most used auxin for plant propagation; it helps to promote roots on many plant taxa. Naphthalene acetic acid is used to promote root formation. It sometimes inhibits root formation. It is often used in combination with IBA.

Table 3. Single component "end use" product availability from Rhizopon and Hortus.

Component	European Union registered	United States EPA registered	Formulation	End use products
IAA	T[z]	Never registered with the US EPA for end use products	Rooting powders used by dry-dip method	Rhizopon[x] A series
	T	Never registered with the US EPA for end use products	Products used to make rooting solutions	Rhizopon A
IBA	T	T	Rooting powders used by dry-dip method	Over 25 end use products
	T	T	Products used to make rooting solutions	Rhizopon AA Water Soluble Tablets Hortus IBA Water Soluble Salts[y]
NAA	T		Rooting powders used by dry-dip method	Rhizopon B series
	T		Products used to make rooting solutions	Rhizopon B

[x] Rhizopon b.v., Hazerswoude, Holland, <www.rhizopon.com>.
[y] Hortus USA, <www.hortus.com>.
[z] Notes that method is used.

Dry-Dip Plant Rooting Products. Dry-dip rooting hormone powders contain one or more of the rooting hormones compounded with an inert ingredient talcum powder (talc) carrier.

United States EPA Registered "End Use" Dry-Dip Rooting Hormone Powders. The most used dry-dip rooting hormone powder concentrations contain 0.1%, 0.3% and 0.8% IBA. Higher concentrations are available for hard-to-root cuttings. Suitable for rooting cuttings by the dry-dip method. (Note: IAA and NAA dry-dip rooting hormone powders have applications for use by the dry-dip method, for use in countries where the "end-use" products are approved.)

Dry-dip rooting hormone powder concentrations higher than 0.8% IBA can often be replaced using water-based rooting solutions by the basal long-soak method.

Products Used to Make Plant Rooting Solutions.

United States EPA Registered "End Use" Products to Make Rooting Solutions.

- **Water-Soluble Products to make Rooting Solutions.** With IBA: as a salt and pre-measured tablets are dissolved in water to make rooting solutions (Rhizopon AA Water Soluble Tablets and

Hortus IBA Water Soluble Salts). (Note: IAA and NAA dry-dip rooting hormone powders have applications for use by the solution methods. For use in countries where the "end-use" products are approved.) Suitable for all rooting solution applications.

- **Alcohol-Based Premixes.** With IBA and NAA: concentrates used to make rooting solutions (from various makers)**.** Suitable for some basal quick-dip applications.

Some "technical use" IAA, IBA, NAA products are insoluble in water; they are soluble in active solvents such as alcohols. Other technical use products are soluble in water or may be able to be made soluble in water.

In the U.S.A., when selecting a product to make rooting solutions read the U.S. EPA label to assure that it has approval for the intended use. The label language, written under U.S. EPA guidelines, states under the Worker Protection Standard the re-entry interval (REI). Some products have approved labels with "zero hour" REI," while others have 24 h REI. (The wording usually states that the workers can not touch the plants for 24 h).

Plant Stomata: Rooting Solution Application and Hydration. Stomata are the minute openings in the epidermis of a leaf through which liquid and gaseous interchange takes place. They are open when the plant is at temperatures from about 60 °F to 90 °F. They are closed when it is cold or hot. The open stomata allow the flow of rooting solution fluids into the plant when using the spray-drip-down and total-immerse methods. If the greenhouse is hot, wait to spray until when the propagation area cools down such as early the following morning. The cuttings should be well hydrated by watering, misting, soaking, and other appropriate methods before treating the cuttings. Using spray-drip-down or total-immerse methods the cuttings may be wet before treatment.

ROOTING SOLUTION TECHNIQUES

Making Up Water-Based Rooting Solution.

- Water is the natural carrier used by the plant. There are U.S.A. EPA registered water-soluble IBA products used to make rooting solutions.
- Alcohol is usually used as the solvent for some forms of IBA, NAA, and IBA. In low concentrations alcohol can cause stem "burn" and stem rot since it can dehydrate plant cells. Some commercial premix rooting solutions use alcohol as the solvent.
- Only use water-based rooting solutions for the basal- quick-dip, spray-drip-down, total-immerse, or the basal long-soak methods.
- Use metric system when calculating the ppm of IBA for making up rooting solutions. It allows easy calculation to any liquid volume and concentration. A rooting solution concentrate can be added to the production tank where the water is added to the proper level. Always make up fresh solutions for immediate use.

SOLUTION METHODS

Application by the Spray-Drip-Down Method. Use the spray drip down method on cuttings that are leafy and are in the growing season.

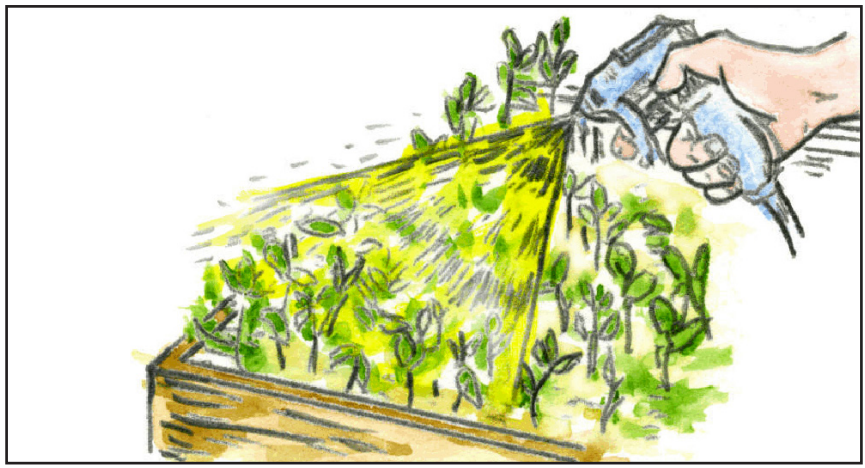

Figure 1. Spray-drip-down method.

- Stick untreated cuttings in the media.
- Spray the rooting solution onto all the leaves uniformly at one time. Use a hand, power or backpack sprayer. Spray the rooting solution until the leaves are fully covered with solution and it drips down onto the media. The drip of solution into the media is an indicator of adequate application.
- Saving labor, production workers do not individually treat the cuttings and do not need personal protective equipment (PPE) since they handle untreated plants. Some growers use thin gloves to prevent contamination from touch.
- The spray-drip-down method uses the rooting solution once thereby eliminating cross phytotoxicity of many plant lots.
- Spray-heads should give a uniform solution emission. A fine mist spray head may apply the solution more efficiently then a coarse spray head.
- Rhizopon recommends using about 1 gal of rooting solution per 175–225 ft^2.
- Apply the rooting solution by the spray drip down method usually within 1 day after sticking, usually at the end of the day when misting is reduced or the following morning.
- If the greenhouse is hot wait until the following morning to spray when it is cooler.
- After application of the rooting solution by the spray-drip-down method wait at least a ¾ h before turning on misters or sprayers. Some growers wait until the solution dries after ¾ h.

Application by the Total Immerse Method. For cuttings that are leafy and are in the growing season.

Figure 2. Total immerse method.

- Totally immerse cuttings, using a basket, into the rooting solution for a few seconds then stick the cuttings in media.
- Total immerse is useful for large production lots of one plant group. It is also useful for large leaf cuttings to assure that the leaves are fully covered with solutions.
- Total immerse can be used on cuttings whose leaves have stomata on the bottom of the leaf where spray drip down is not suitable.

Rates for the spray-drip-down and total-immerse methods during the growing season**:** Adjust rooting solutions concentration rates based upon practical experience.

- Perennials plants: @ 500–1500 ppm IBA (approximate range as suggested by Yoder Greenleaf Perennials).
- Ornamental plants (such as viburnum, syringa, rosa cultivars): at 750–1500 ppm IBA

Application by the Basal Quick-Dip Method. Basal quick-dip method is used on plant cuttings that are leafy or leafless and are propagated in the growing season or dormant season.

Figure 3. Basal quick-dip method.

- Immerse the basal end of the cuttings into the rooting solution for a few seconds then stick the cuttings in media.
- Woody cuttings often need to have wound cuts made at the basal end before treatment. It is not necessary to wound herbaceous cuttings.
- Rates for the basal quick-dip method during the growing season or winter cuttings: There is extensive published data for basal quick-dip rooting solution rates; typically at 100–8000 ppm IBA.

Application by the Basal Long-Soak Method. For plants that are known to root slowly.

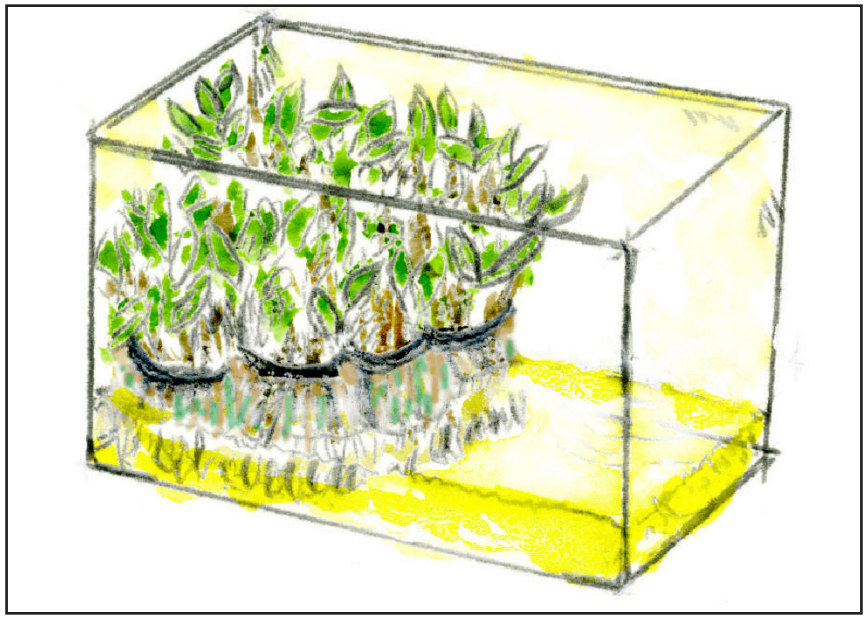

Figure 4. Basal long-soak method.

- Soak the basal ends of the cuttings in a water-based rooting solution so they slowly absorb the rooting hormones.
- After treatment either stick the cuttings in media or store.
- Rates for the basal long-soak method during the growing season or winter cuttings: Use rooting solutions at 25–150 ppm IBA. Soak the basal end about 12 h then plant or store. Typical plants: prunus root stocks, London plane tree and Japanese umbrella pine, leafless winter cuttings, and some *Hedera* and *Vinca.*

DRY-DIP METHOD

Choosing Dry-Dip Rooting Hormone Powders. Dry-dip rooting hormone powders have been used for plant propagation since the 1930s. The powders are used by the dry-dip method. The powders overcome seasonal variation in rooting and are used to root leafy cuttings in the growing season, and leafless and winter cuttings. The powders are always ready to use to treat a few or many cuttings. To use, only take out from the package what is need for the rooting session. Production can be changed from variety to variety throughout the work day using different products. Commercial rooting powders are available in several IBA concentrations.

Table 4. The most popular IBA dry-dip rooting hormone concentrations.

0.1% IBA	Root cuttings of house, foliage, tropical and hardy ornamental plants. Herbaceous, leaf, greenwood, and softwood cuttings.
0.3% IBA	Root cuttings of house, foliage, tropical and hardy ornamental plants. Herbaceous, greenwood, softwood and hardwood cuttings.
0.8% IBA	Root cuttings of more difficult-to-root woody ornamental plants. Softwood and hardwood cuttings.

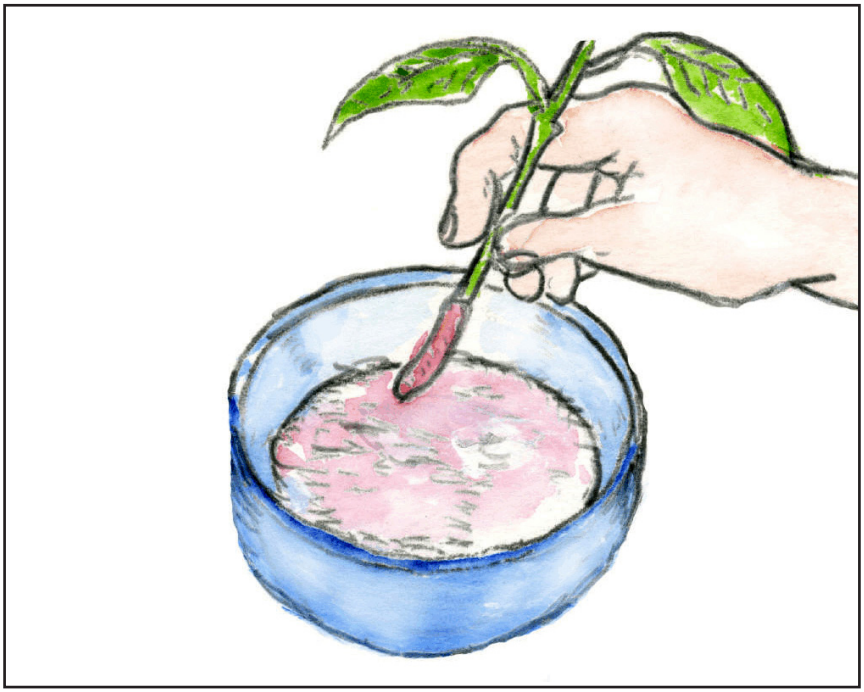

Figure 5. Dry-dip method.

Application by the Dry-Dip Method.

- Woody cuttings often need to have wound cuts made at the basal end before treatment. Herbaceous cuttings are not wounded.
- Dip the cuttings about a ½ inch into the dry-dip rooting hormone powder. Tap off any excess powder for uniform powder coverage.
- Then, stick the cuttings in media.
- Roots can be expected to form where the cuttings are covered with the powder.

DRY-DIP VS. ROOTING SOLUTIONS

- It is not possible to say that dry-dip rooting hormones or rooting solutions are universally better. Some plants root better with dry-dip or solutions based upon the time of the year that the cuttings are taken, the age of the mother plant, and the cuttings.
- Physiologically and biologically young cuttings need a lower rooting powder concentration than older cuttings. Do tests to determine the best solution or the best dry-dip method.
- For waxy leaf cuttings use the dry-dip method or total immerse method.
- Root hard-to-root cuttings, either leafy or leafless: the basal long-soak method is often better than using high-concentration dry-dip rooting hormone powders.
- Root leafless cuttings during the growing season: the dry-dip method is often better then the basal quick-dip or basal long-soak methods.

STORAGE OF ROOTING PRODUCTS

Storage of Dry Plant Rooting Products. If kept dry, at normal room temperature, dry rooting products will be active for many years.

- Moisture: Store the dry powders in their original containers to prevent caking.
- Light: Keep the dry powders out of bright light for long periods.
- Temperature: Normal room temperature is adequate for keeping the dry powders. Refrigeration is not necessary to keep the dry powders.

Keeping Life of Rooting Solutions.

- Mix a portion of the solution for the same day use.
- Dispose of unused portions.
- If a solution is used by a method where the plant is dipped into a solution: dispose of the solution at the end of the day.
- It is prudent to dispose of solutions in unlabeled containers to avoid mis-identification.

A Dutch independent lab [SGS-CTS Agri Foof Laboratory, Spijkenisse, The Netherlands (May 25, 2008)] did tests on water-based rooting solutions with Rhizopon AA water-soluble tablet and Hortus IBA water soluble salts: stored in dark, at 68 °F (room temperature, at 5 days the solutions were at full strength.

Keeping Life of Dry-Dip Rooting Hormones.

- Always take out the rooting powder for current needs.
- Do not return the used portion to the original container.
- Dispose of the used portion.
- During the dipping process there is a drag into the powder of pathogens that will contaminate and biologically break down the powder.

IMPROVING ROOT DEVELOPMENT

Leafy Cuttings in the Growing Season Which Are Already Treated and Are Slow to Develop. Stimulate faster root development by applying rooting solutions by the spray-drip-down applications at 50–150 ppm IBA. Some growers use rates at 500–1000 ppm IBA weekly.

When Propagating Plants by Tissue Culture. When transplanting the plantlets they may not have working stomata. Use the total-immerse method to apply the water-based rooting solution at 100–300 ppm IBA then plant.

After the first new leaves appear and plantlets are in an advanced state of development apply rooting solutions by the spray-drip-down method at 100–300 ppm IBA.

CONCLUSION

Cuttings can sometimes develop roots without applying external root-inducing chemicals to the plant material. Many plants, however, need chemicals applied to the plant parts in order to help plant cells divide and form new root systems.

Indole-3-acetic acid, IBA, and NAA have been used successfully for more than 80 years to induce adventitious root formation. The "bio-simulators," IBA and NAA, act on plants like IAA. Rooting hormones can be applied to the cutting basal end where we intend root formation. Propagators can also apply them to the leaves of plants during the growing season where the plant rapidly translocates the hormones to the basal end.

Basal Application. Basal application of the rooting hormone can be applied using either rooting solutions or dry-dip rooting hormone powders. Rooting solutions can either be applied by basal quick-dip application for a few seconds, usually using high concentrations of rooting hormones, or we can also apply the solutions by basal long-soak method for several hours, using low concentrations. Dry-dip rooting hormone powders, used by the dry-dip method, are available in a range of premixed products. After treatment the cuttings are stuck. The basal treatments can be used for leafy cuttings in the growing season and, leafless cuttings in the growing season and in the winter. They can be used for hard-to-root cuttings any time of the year.

Foliar Application. Foliar application of the rooting hormone can be applied using water-based rooting solutions. The solutions can be applied by totally immersing the cuttings in the solution for a few seconds and then sticking the cuttings. The solutions can also be applied to the cuttings by spraying onto leaves of the cuttings after they are stuck. Foliar treatments can be used for leafy cuttings in the growing season. Water-based rooting solutions are suitable for these applications since organic solvent-based solutions can kill sensitive plant tissue.

The foliar applications are favored by growers since production labor is reduced and the plants are treated uniformly. The spray application of water-based rooting solutions has the advantage of eliminating cross contamination of pathogens between production lots.

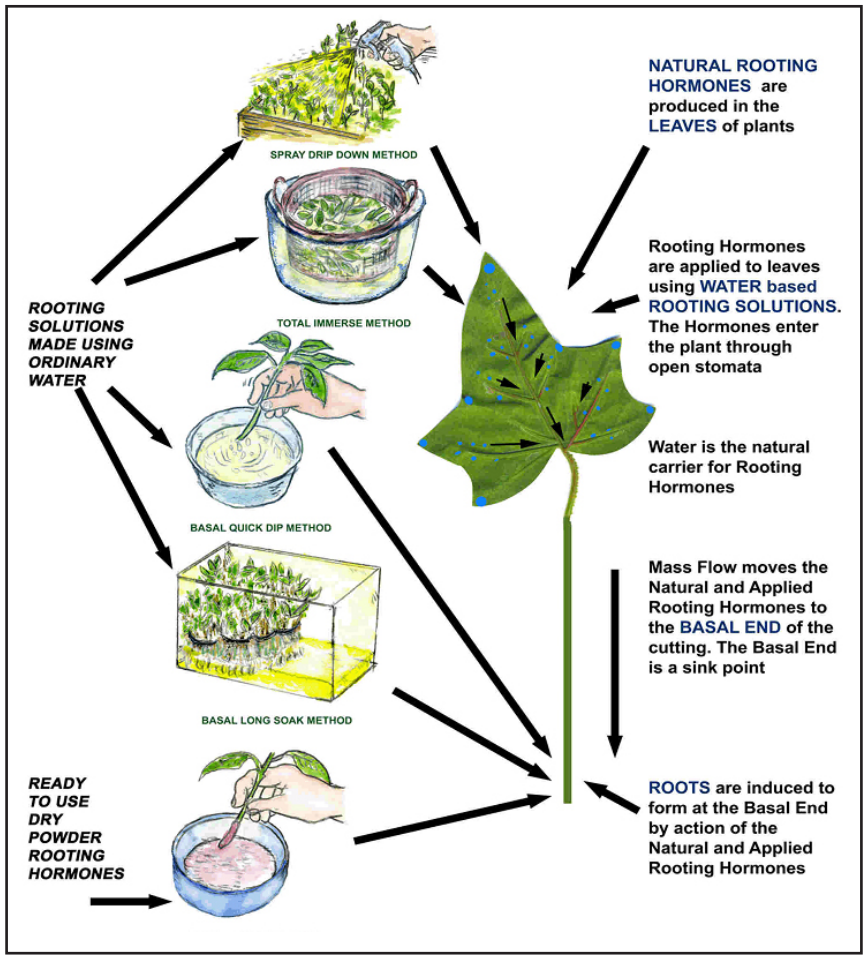

Figure 6. Summary of application metehods.

Most plant cuttings produce roots better when taking cuttings in the growing season. Therefore any of the methods described are applicable. In the winter the basal methods are suitable.

Whether using water-based rooting solution or a dry-dip rooting hormone powder the plants avoid problems associated with solvent-based rooting solutions. Solvents like alcohol can injure basal stem tissue and result in killing or severely injuring cuttings during treatment. Water-based solutions avoid these problems of solvent-based solution.

It is not possible to say that dry-dip rooting hormone powders or rooting solutions are universally better. Five methods of application were presented: dry dip, basal quick dip, basal long soak, spray drip down, and total immerse. Each method has distinct uses which must be tried out for effectiveness and material and labor costs.

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