REGULATION OF PLANT GROWTH BY RAIN AND MIST

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Abstract Rain and mist have many effects upon plants other than providing water, including leaching of important metabolites, and influencing patterns of rooting, development of fall color, dormancy, flowering, and plant interactions. Changes in growth observed in cuttings propagated under intermittent mist are also observed in plants grown commercially with overhead irrigation and in areas of high rainfall. Rain and mist are significant factors in plant growth.

Every plant propagator knows the tremendous influence that mist has had on plant propagation. Cuttings of many plants which were previously propagated as hardwood cuttings in the dormant season can now be propagated much more rapidly as softwood or greenwood cuttings during the growing season. Combined with the use of auxins, mist has revolutionized the plant propagation industry.

The success of mist has been attributed to two major factors (3). Mist cools the leaves and stems of cuttings and raises the relative humidity of the air, reducing the vapor pressure gradient between the plant and the outside air, thus reducing transpiration. Cooling of the leaves reduces the rate of respiration which helps to maintain carbohydrate levels in the cuttings. However, there are other effects, for plants and cuttings grow well under mist and rain.

One of the most important actions of rain and mist is the leaching of metabolites from plants (1, 7). Mineral nutrients, amino acids, carbohydrates, and growth regulators can be washed out of stems and foliage, often in large amounts. Leaching occurs from all types of plants, and the wide range of different metabolites that can be leached makes this an important plant process affecting yield, quality, and pest susceptibility. Substances which are leached from one plant can be reabsorbed by plants growing beneath or nearby with significant effects. For example, inhibitors leached from one plant can completely or partially suppress the germination and growth of other plants nearby. Known as allelopathy (7), this phenomenon is particularly well documented in desert communities but also is known in landscape situations. Junipers make good ground covers due in part to toxic materials which are leached from the juniper foliage. In natural communities, some plants are dependent almost completely for their nutrition upon the materials leached from plants overhead. Thus, the interaction of plants in both landscape and natural conditions is greatly affected by materials which are leached out of the leaves and cycled from one plant to another.

Leaching occurs from cuttings under intermittent mist (1) and it is a common practice for some plant propagators to add nutrients through the mist to those cuttings susceptible to leaching. Nutrient mist applications also provide nutrients for the new growth that occurs under intermittent mist (8). Thus, leaching of metabolites is an important process by which rain and mist affect the development of plants.

Another interesting effect of mist is on the development of dormancy in woody plants (2, 6). Normally, woody plants such as *Euonymus alatus* begin preparation for winter in mid-summer. Growth slows, sugars accumulate, leaves turn red and abscise in the autumn, and the plant becomes dormant, requiring about 6 weeks of cold temperatures to resume growth. However, when euonymus plants were grown under intermittent mist during the late summer and early fall, they did not become dormant and the leaves did not become red and abscise. Instead, leaves remained green and plants continued to grow through the winter season if warm temperatures were maintained. In fact, the plants did not become dormant for periods of up to 2 years if kept under the mist. However, when the plants were removed from the mist, they immediately responded as if it were the fall of the year; red foliage developed, the leaves abscised, and the plants became dormant, even if this occurred during the middle of summer.

Since the growth regulating chemical abscisic acid (ABA) has been correlated with dormancy in many woody plants, we determined levels of ABA in both the misted and non-misted euonymus (2). ABA in non-misted plants increased gradually during the late summer and early fall and then increased rapidly at the time red color was developing and the leaves were abscising. In contrast, in plants under mist, ABA remained at a low level as long as the plants were under the mist, but increased rapidly when the plants were removed from the mist. Further, we detected ABA in the leachates from the misted plants. This suggested that the delay in dormancy was due to leaching of ABA by the mist.

Another example of the effect of rain and mist is in the development of fall color in the foliage of some shade trees and ornamental shrubs (6). The red color which is so prized in the autumn is due to the accumulation of anthocyanin pigments which are derived from sugars stored in the leaves. It was observed that during a rainy autumn the intensity of red colors in maples was not nearly so striking as during a year with less rainfall. This suggested that something having to do with synthesis of anthocyanins might be influenced by the rain, perhaps sugars or some other precursor.

When *Euonymus alatus* plants were grown under mist, anthocyanins did not develop, and the leaves remained green. In control plants grown without mist, anthocyanins developed normally.

Analysis of the misted plants showed that levels of sugars, precursors of anthocyanins, were lower in the misted plants than in the non-misted. Further, the metabolism of the misted plants was altered so that colorless leucoanthocyanins were produced rather than the red-colored anthocyanins. Other factors associated with anthocyanin synthesis, such as nutrition and temperature, were not responsible for the observed effects.

Mist can also have an appreciable effect upon rooting, as we have reported previously (5). When euonymus plants were analyzed for substances associated with rooting, we found that levels of auxins, carbohydrates, enzymes involved in the formation of auxins, rooting cofactors, and other flavanoid compounds were all much higher in plants and cuttings grown under mist than in plants which did not receive the mist. No wonder that cuttings under mist rooted so much more quickly than did similar cuttings without the mist. Therefore, mist affects rooting not only by cooling leaves and reducing transpiration, but also leaching substances from the cuttings, and inducing cuttings to form natural compounds which stimulate the rooting process.

Another effect of rain and mist is in flowering (4). It is commonly observed in the warm humid tropics that plants often flower in relation to rainfall. In the chrysanthemum which is induced to flower by short days, misting the plants can delay flowering if mist occurs before and immediately following the application of short days. In the case of the Japanese morning glory (*Pharbitis nil*) the results are even more striking. If *Pharbitis*, which requires only one short day (one long night) to flower, is grown under intermittent mist, flowering can be completely inhibited regardless of the photoperiod treatment. Here is another example of how rain and mist can completely change the growth patterns of a plant.

These changes in metabolism of ornamental plants induced by rain and mist can be observed in other crop plants growing throughout the world. For example, in the San Joaquin Valley of California, commercial grape growers use overhead irrigation to reduce the mid-day temperatures during summer. The leaf temperatures are indeed reduced, but in addition, the flowering patterns of the grapes are changed somewhat, the sugar content of the fruit is increased and the resulting wine product is of higher quality. This is important because the use of overhead irrigation to ameliorate environments of crop plants is increasing, including fruit and vegetable crops as well as landscape plants.

In the Pacific Northwest and other fruit regions, fruit crops are being grown in closely planted hedgerows with overhead irrigation. Large increases in both production and quality have been noted as compared with plants without overhead irrigation. Tea of high quality is produced in areas of India where mist and fog are prevalent;

leaching by the mist is recognized as an important factor. Gardeners and nurserymen comment on the luxuriant growth of woody plants in areas with rain and mist, such as the British Isles or the Pacific Northwest. In the warm humid tropics, lush plant growth is often associated with the warm temperatures. However, if those same tropical plants are grown at warm temperatures but without the constant bathing of the rain, growth does not occur to the same degree.

Thus, mist and rain affect plants by cooling the leaves and reducing transpiration and respiration, by leaching of substances,and by influencing the development of fall color, root initiation and development, dormancy, and flowering. All of these are good examples of how a research interest in ornamental horticulture can have appreciable implications throughout the world, in production of economic plants and in natural plant communities. Rain and mist assume even greater significance as factors in plant growth and development.

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BILL CURTIS: I want to comment on magnolia propagation; we found that on plants that have pith we get much better rooting if we cut beneath the node. We also use a bottom heat around 80°F, pour the water to them, and *Magnolia grandiflora* roots 100%.

DICK BOSLEY: I started using Benlate and 2% IBA on rhododendrons several years ago and each year our rooting percentage got poorer. Last year we went back to using Captan and IBA and our rooting percentage went back up to where it used to be. I'd like you to comment on the fact that you're using 4% IBA, which I would normally consider to scald rhododendron cuttings, and what is there about Benlate which retards rooting?

JOHN MCGUIRE: I have seen the reports of reduction of rooting with the use of Benlate but I have never observed it in practice. In addition there are 8 nurserymen in Rhode Island who use it regularly and I don't believe any of them have ever experienced this effect.

With respect to the 4% IBA, I'm speaking about the commercial product Hormex which is a very light fluffy material and I don't believe it is the percent in the formulation but rather how much you get on the cutting. Because this material is light and fluffy you don't actually put a lot of it on. I would agree that a 4% quick-dip or a high concentration of Hormodin will burn them. I believe the problem with Benlate has to do with the environmental conditions you put the cuttings under. Apparently if you put the cuttings under a high bottom heat condition, such as they're doing in Holland, you do get injury; however we're using lower bottom heat and we get no injury.

The magnolias were rooted under outdoor mist with no bottom heat but the ambient temperature in the summer may be as much as 90°F.

VOICE: Dr. Albert, if you're using a 2% IBA talc rooting powder how much boron would you put in it to test its effect on rooting of cuttings?

LUKE ALBERT: I wouldn't use any more than 50 to 100 ppm. It is interesting to experiment with boron; if any of your wives are rooting cuttings at home in a glass of water put in a little boric acid from the medicine cabinet; you will often be surprised at the results. Where root initials would be formed and just sit there, with a little boric acid in the solution, the roots will grow out and you will have some nice rooted cuttings.

RAY MALEIKE: Isn't it true that root length will be shortened by the use of excessive IAA?

LUKE ALBERT: Yes and high levels of boric acid will do this also; in this sense high levels of boric acid mimic high IAA.

BILL CURTIS: When Jiffy Grow first came out it had boron in it. That year we had some bearberry and some *Gaultheria* cuttings in the bench which just sat there without rooting. Ed Wood suggested I spray the cuttings with Jiffy Grow which I did and in 3 weeks we were potting them up.

Thursday Morning December 4, 1975

The first portion of the Thursday morning program was moderated by Dr. Dale Herman and the second half by Mr. Leslie Clay.