Dealing With Disease in High Humidity Environments: Strategies for Control in Fog and Mist Zones

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INTRODUCTION

The purpose of this presentation is to discuss, in practical terms, the nature of plant disease in high humidity propagation houses utilizing fog and mist systems, and to present workable, tested control strategies from both research and personal experience. An integrated approach to disease management is crucial, since chemical control alone is seldom effective. There is no one strategy that will, by itself, control pathogens under the intense disease pressure that exists in fog and mist houses. However, good control is possible by utilizing many different strategies.

DEFINITION OF DISEASE

Disease, in the broad sense of the word, refers to any negative deviation from normal growth patterns and development. Diseases are usually classified as biotic – those caused by a pathogen — and abiotic — those caused by something other than a pathogen (such as nutritional disorders, insect damage, water stress, or mechanical injury). The focus of this discussion is on biotic, or pathogenic diseases. Some factors which increase the likelihood of disease in propagation houses are the wounding of plants (an unavoidable part of stem cutting), plant stress due to lack of roots for water uptake, a humid environment which is conducive to certain pathogens, presence of insect vectors of disease such as fungus gnats and shore flies, and high temperatures.

THE DISEASE TRIANGLE

In order for a disease to develop, three factors must be present; the host plant, the pathogen, and a favorable environment. Taken together these are referred to as the disease triangle. Disease cannot develop in the absence of one of these factors. The host is the susceptible plant, the environment must be conducive to the growth, development, and reproduction of the pathogen, and of course the pathogen must be present. Disease can be prevented or curtailed by interrupting one or more of these factors. This applies to disease control in general, and we will look at how to apply this in the special challenge of a high humidity propagation environment. Strategies have been categorized based on which part of the disease triangle they impact.

STRATEGIES TO LIMIT OR ELIMINATE DISEASE DEVELOPMENT

The Host. Leg 1 of the triangle – the host. A susceptible host must be present for disease development.

Cultivar Selection. There are some diseases that are not very host-specific and others that are. We can see differences in susceptibility within a species of plant. Therefore, one strategy for disease control is to select resistant cultivars. However, under conditions in which the plant is stressed, and the environment is very favorable for disease development, even resistant plants can succumb to disease. Cultivar selection based on disease susceptibility alone may not always be feasible. For example, within the species *Salvia ×sylvestris* 'Mainacht' (syn. *S. nemorosa*), the cultivar 'May Night' is highly susceptible to *Rhizoctonia* stem and leaf rot in a high humidity environment. But we do not want to eliminate that cultivar from production – it was the Perennial Plant Association's Plant of the Year in 1997 – a very popular cultivar. In this case, the only alternative is to learn to control the disease.

Stock Plant Selection. Another important factor in manipulating the "host" leg of the triangle is to be sure to take cuttings from healthy, vigorous stock plants. Many times a plant only becomes a susceptible host when it is under stress. How well trained is the crew that actually takes the cuttings? Do they know how to distinguish between a healthy stock plant and one that is under some kind of stress? They should be trained to look for warning signs such as chlorosis, wilt, leaf spot, insect infestations, and stunted or distorted growth. Sometimes there will be a significant difference among plants of the same cultivar growing in fields or stock gardens. The differences can be a result of uneven irrigation, insect infestation, uneven fertilizer application, or some other cause. Cuttings taken from a stressed stock plant are going to be much more susceptible to disease once in the high humidity environment.

The Pathogen. Disease cannot develop without the presence of the pathogenic organism. There are many strategies for excluding or reducing the number of pathogenic organisms in the propagation house.

Stock Plant Health Management. Never bring diseased plant material into the propagation area. Stock plants should be scouted and treated for disease prior to cuttings being taken. Since fungicides are most effective as a preventive treatment, it may be feasible to have all stock plants on a regular fungicide treatment schedule. One thing to remember, though, is that the specific diseases that occur in a propagation house may be different from the diseases to which the plants are susceptible in their regular growing environment. Therefore, the general or broad-spectrum fungicide that is routinely applied to the stock plants may not be effective for the specific diseases that will be encountered in fog or mist zones.

Sanitation. Sanitation begins with the area in which the cuttings are being stuck. Diseases can easily be spread from plant to plant by not disinfecting cutting tools or workers' hands. Cutting benches should be disinfected regularly. There are products available to disinfect both the work space and tools and even the plant material being brought in. We dip cuttings before sticking them in a 0.5% to 1.0% solution of Zero Tol to kill any disease spores that may be present on the plants. Work benches are cleaned daily with either Naccosan or Green Shield. All the workers wear disposable gloves.

Make sure your medium is clean. Do not store your media where it can be contaminated with soil. Flats and pots should be new or have been cleaned with a disinfectant before re-use. The propagation house should be thoroughly cleaned and disinfected when it is empty. If there is a time in summer when a section of the house is not in use, disinfect or sterilize it, then allow it to bake. If possible, close vents and allow the temperature to rise. Not too many disease organisms are going to survive above 100°F. for any length of time.

Even if the fog or mist zone is in use, there are still some products you can use. Bromine (Agribrom) and Zero Tol are safe to use on most plants and both kill or prevent algae. These products have no residual, so frequent applications are necessary. These can be injected directly into the fog or mist system at low rates or can be sprayed over the top of the plants.

Water Quality. Water can bring in a whole host of problems, including spores of *Pythium* and *Phytophthora*, algae and liverwort spores, pH problems that affect nutrient uptake and toxicities from heavy metals. It is important to have water tested to know what potential problems may arise in order to take the necessary measures to correct the problem. Some water sources will never be acceptable for propagation and it is good to know that before investing money in a facility. There are many labs available that will do an "irrigation suitability" battery of tests. Testing for particular pathogens is done by some laboratories. OSU Extension offices have a list of local labs for Oregon.

There are many products that can be injected directly into the water being used for fog, mist, and irrigation in order to kill spores of fungus, bacteria, moss, and liverwort. We are trying a fairly new system that injects charged copper ions into the water system. Zero Tol, bromine, and chlorine are other options for injecting into irrigation water. Injecting some type of disinfectant/sterilant into the water system is useful for sanitizing the water itself, and to some degree the surfaces that the water touches, so it may be useful in controlling algae and foliar fungi. This strategy will not control soil-borne pathogens, however. Most of these products will neutralize quickly once in contact with organic matter.

Pest Control. Controlling pests is an important element in controlling diseases, since many insects are vectors of disease. One of the most important pests in propagation houses is fungus gnats. Not only will the larvae cause damage to young plants by feeding on the developing roots and invading cut stems, but the adults vector fungal and bacterial diseases. Since the adults are primarily algae feeders, controlling algae will help to control these pests. This can be done by removing flats as soon as the plants start to root – the longer the plants are in the propagation area, the more algae will develop.

Fungus gnats can be controlled biologically and chemically. We use predatory mites that feed on the larvae (*Hypoaspis miles*), and that program has been very successful in suppressing populations. There is also a parasitic nematode (*Steinernema* spp.) available, under the trade name Nemasys, that gives more effective knock-down if you already have high populations of gnats. Gnatrol is a Bt (*Bacillus thuringiensis*) product also useful for fungus-gnat larvae control. Several insect growth regulators target the larval stage, including Distance, Precision, and Enstar. In order to contact the larvae, these can be applied as a spray and then watered in.

Biological Disease Control. Controlling disease microorganisms with beneficial microorganisms is another strategy. This is especially useful for soil-borne diseases. Many products are available to inoculate the media with beneficial fungi and bacteria. Some of them work by actually antagonizing the disease organisms and others work by out-competing them for available space, nutrients, etc. When using sterile media, it is important to be aware that the first microorganisms to invade that media will have a competitive advantage. Incorporating beneficials into the media prior to planting will give these organisms a chance to establish prior to invasion of the media by pathogenic organisms.

Chemical Control. When treating with preventive fungicides, it is generally preferable to treat stock plants prior to taking cuttings. However, there are circumstances where chemical sprays in the propagation house are in order. Some diseases will only develop when the plants are exposed to high humidity. For example, *Rhizoctonia* may be present in the field and never cause a problem on the plants, but once the cuttings of a susceptible plant are taken and put in 95% humidity, disease may occur. In that case, a very specific fungicide will protect those cuttings. Good record keeping will help in determining, over time, which plants will have problems in the fog/mist zones. It is important to correctly identify the disease organisms that are causing the problems, in order to treat them effectively. Guesswork can end up costing a lot of money, so it is best to use a lab to get a confirmed diagnosis.

Why not just treat everything in the propagation house with a broad-spectrum fungicide? First, such a treatment would be a waste of chemical and time. Many crops won't require the fungicide treatment. Also, narrow-spectrum fungicides that target a particular organism are often much more effective against that organism. This is the case especially with *Botrytis* and *Rhizoctonia*. There are many chemicals labeled for these diseases, but many of the broad-spectrum products are not very effective. And it is not cost effective to spray the whole house with narrow spectrum products, unless a specific organism is causing wide-spread problems. To control specific known organisms on hosts that are only susceptible in the high humidity environment, a chemical application immediately after sticking with a chemical which specifically targets that pathogen is often the least expensive and most effective option. In addition, the repeated use of fungicides may cause resistant strains of pathogens to develop. Finally, the use of chemicals reduces the amount of time that employees can work in the greenhouse due to re-entry intervals and increases employee exposure to chemical residues.

THE ENVIRONMENT

The environment must be conducive to the growth and development of the disease-causing organism for disease to occur, so that is one area that can potentially be manipulated to suppress disease. However, the environment also has a great effect on rooting percentages and the time it takes for cuttings to root. Sometimes the choice must be made whether to manipulate the environment to the detriment of disease or to the benefit of the plants. In general, the environment in a propagation house should be manipulated for optimum rooting and growth of the crop plants, regardless of the effect on disease organisms. It must be remembered that disease is the result of interplay between the pathogen and the host. The conditions that favor pathogen development in a laboratory will not necessarily favor disease development in a crop production system. For example, it was shown under laboratory conditions that the fungus *Pythium ultimum* had optimum growth at 27°C. So one would think that avoiding that temperature range would suppress that disease. But in a crop of poinsettias, it was found that the optimum temperature for disease development was 17°C (Bateman and Dimock, 1959). The difference could be due to the fact that 26°C was the optimum temperature for root development of the poinsettias, so at that temperature the plant was growing vigorously, making it less susceptible to disease. In this case, the environmental conditions that would ordinarily have favored the pathogen did not lead to disease development, because the plant was able to outgrow the pathogen.

Temperature. The warm temperatures usually maintained in a propagation house are in the optimum range for several important pathogens. One can look at a table to determine the temperatures at which certain diseases are likely to develop in a particular crop. This information is, in practicality, of limited use to most growers. It is often specific to a particular crop and varies with geographical location and other variable growing conditions. Although it may not be practical to regulate greenhouse temperatures according to information in a table, in order to avoid a particular disease, the information is still useful to determine which organisms are likely to be present and active in the propagation house. Fungal organisms whose optimum temperatures for pathogenicity are in the range found in most propagation houses (70 to 90°F) include *Alternaria, Fusarium, Rhizoctonia, Botrytis*, and *Pythium aphanidermatum*. *Xanthomonas, Pseudomonas*, and *Erwinia* are important bacterial diseases that also develop under high temperature conditions. (Jarvis, 1992)

Humidity. Humidity plays a crucial role in the rooting of stem cuttings. High humidity also favors a myriad of fungal and bacterial disease organisms. For the majority of plants propagated by stem cuttings, humidity around the cuttings must be high in order to maintain turgidity and prevent desiccation. This is especially true of soft material, both woody and herbaceous. We have seen a positive correlation between increased humidity and speed of rooting in many species of plants. It is important to maintain humidity around the cuttings from the time they are cut from the stock plants until they are rooted. We experienced an increase in rooting percentages of many crops as humidity was raised in the fog house to over 95%. Of course, this is not true for all plants. Having a choice of zones for propagation is important if you are propagating a wide variety of plant material. We use fog in four zones, each with separate humidity controls, as well as greenhouse and outdoor mist beds. In most areas, humidity is maintained to promote rapid rooting. For some succulents and plants that do not require high humidity, the zone is maintained to prevent desiccation, but at low enough levels to suppress disease.

It may be possible to delay the onset of disease by maintaining a lower humidity, but if this delays root development and causes the plants further stress, you may end up with more loss from disease and from desiccation in the long run.

Soil Moisture. Most soil-borne diseases are affected in one way or another by the amount of moisture in the soil. Diseases which are more prevalent under conditions of high soil moisture content include *Pythium, Phytophthora*, and *Thielaviopsis*. It may be possible to reduce the incidence of these diseases by maintaining soil moisture at lower levels. However, since some water is taken up by the cut stem, in the absence of roots, adequate moisture in the media is necessary in order to maintain turgidity of the cuttings.

Several factors need to be taken into account when considering irrigation. If the humidity is too low, more irrigation is necessary. The splashing from overhead watering can spread disease. Therefore, any disease suppression benefit obtained from lower humidity may be lost due to movement of fungal spores by splashing water.

If irrigation can be managed without overhead watering, that will help in disease suppression. Work has been done using subirrigation in conjunction with fog and mist, and without fog or mist, in propagation of stem cuttings. If the humidity is high enough, depending on the time of year, additional irrigation may not be necessary.

Air Movement. Good air circulation is crucial in controlling disease. Air movement can be created using fans, or will occur as a result of natural ventilation (i.e., roof vents). Using wire mesh benches encourages air movement in the area around the plants. Since warm air rises, using bottom heat causes an upwards movement of air in the canopy. Horizontal air flow fans will keep air in circulation. In a fog house, it is not desirable to keep up a strong draft because that will create uneven humidity that can lead to uneven rooting. The house should be properly ventilated with gentle air movement in and around the plant canopy.

TIME

Time is a factor that may turn the disease triangle into a 4-sided pyramid. It takes time for disease development. The longer plants are kept in fog or mist, the more susceptible they become to certain diseases. We have seen that in cases of uneven rooting within a flat of plants, the more vigorous plants, which rooted first, may succumb to disease because they are left in the fog too long waiting for the stragglers to root. When this happens, the best plants are lost for the sake of the weakest! It is wiser to move the flats out before disease can get started on the first plants to root, and if plants are lost, it will be the weaker ones which are taking longer to root. It is a good idea to get the plants out of the high humidity environment as soon as possible. Of course, use good judgement concerning the time of year; don't move plants with few roots to a dry area when it's 90°F. Often, an intermediate area where the young plants are protected by shadecloth until they are well rooted is advisable.

CONCLUSION

From the time stem cuttings are placed in a high humidity environment, a race begins between the host plant and the pathogens. If the conditions are such that the host plant will root quickly, it may win the race and be able to be moved out of the humid environment prior to the onset of disease. However, if the host is slow to root, due to some type of stress or to the genetic nature of the plant, the pathogen may "outrun" the host, and the cutting may be lost to disease.

We must do everything we can to "stack the odds" in favor of the plant. This can be done by manipulating the environment such that it favors rapid root development, protecting the cutting with fungicide to slow or prevent disease development, lowering the population of the pathogenic organisms through sanitation, selecting only the strongest, healthiest cutting material, inoculating the cutting media with beneficial microorganisms to suppress pathogens, and selecting cultivars which have genetic resistance to disease organisms.

LITERATURE CITED

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