NYSFG New York State Flower Growers

INCORPORATED

BULLETIN 186 Secretary, Charles Wilton, Prattsburg, Steuben Co., N. Y. MAY, 1961

Environment and the Poinsettia Root Rots

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The root rots of poinsettia caused by *Thielaviopsis basicola* (Berk. and Br.) Ferraris, *Rhizoctonia solani* Kühn, and *Pythium ultimum* Trow are the most serious diseases associated with this commercial crop when grown under glass. Losses in recent years, however, have not equaled those experienced back about 1950 before "complete sterilization" was recommended for poinsettia culture, nor are they as general. Many of the losses which have occurred in recent years have been the result of recontamination of sterilized potting soil or some omission in the over-all program outlined by Dimock and Bateman in the New York State Flower Growers Bulletin 151, July, 1958. When recontamination occurs these diseases are often more devastating than ever, since the pathogens no longer have to compete with the normal soil flora for available food and space.

The three fungi that cause poinsettia root rots are perhaps plentiful in many commercial greenhouses since all of them can live in the soil in the absence of poinsettia or may attack many plants other than poinsettia. Extensive efforts have been made to use available fungicides as a stop-gap measure in case of recontamination, but many results along these lines have been disappointing, particularly where the identity of the recontaminating pathogen or pathogens was not known or where the disease problem was not recognized in time. Since the pathogens can and often do occur in combinations, the measures necessary for adequate disease control become greatly complicated. It has been recognized for some time that Terraclor can be used as a stopgap measure to control *Rhizoctonia*, and Captan has sometimes given good control of *Pythium*.

However, when *Thielaviopsis* has been involved none of the available fungicides tested have given the desired degree of control. Since the pathogens may occur in any combination and the grower is not usually aware of the particular organism or organisms he is trying to combat, attention recently has been focused on the role of environment in the development of these diseases and disease complexes, in the hope of obtaining information useful in achieving a more effective control.

The environmental factors expected to have the most important effects upon development of the poinsettia root rots were soil temperature, moisture, and pH. The objectives in the present work were to determine the influence of each of the above environmental factors upon disease caused by each pathogen individually, as well as the influence of each environmental factor upon development of the various disease complexes, and to determine the combination of environmental factors which would result in minimum disease development regardless of the pathogen or pathogens present.

Materials and Methods

Poinsettia cuttings for all experiments were selected for uniformity from stock plants of the variety Barbara Ecke Supreme.

The cuttings were rooted in a rooting tray provided with adequate drainage and equipped with an electric heating element that maintained a temperature of about 79° F. in a vermiculite rooting medium. All cuttings were rooted under intermittent mist. Under these conditions the rooting period was between 15 and 20 days, even during the winter months when supplementary light was provided.

The *Thielaviopsis* isolate used in this work was obtained from roots of poinsettia stock plants at Ithaca in May, 1957. Both the *Pythium* and *Rhizoctonia* isolates were isolated from diseased poinsettia plants in North Carolina in September, 1957 by Dr. A. W. Dimock.

In experiments in which the influences of soil temperature and moisture upon the development of disease initiated by each pathogen were evaluated, a soil mixture consisting of 1/3 sand, 1/3 peat, and 1/3 field soil by volume was employed. This mixture had a pH of 7.0 after autoclaving for 2 hours at 15 lbs. pressure. This same soil mixture when saturated contained about 56% moisture when expressed on a dry weight basis. In the moisture experiments soil moisture was expressed as the per cent of the moisture holding capacity (% MHC) of the soil based on dry weight measurements.

Soil temperature was controlled with ±2° F. of the indicated values by using the Cornell temperature tanks. In the temperature study a high soil moisture level was used throughout. The temperature range employed from 55 through 86° F. at 8° intervals. Soil moisture was controlled by using different vertical depths of a sand-vermiculite medium above a constant water table maintained in metal greenhouse sub-irrigation benches. With this system soil moistures near 30, 50, 70, and 85% MHC were obtained in 2½ inch pots of soil embedded in the surface layers of the sand-vermiculite medium 12, 8, 5, and 3 inches above the constant water table.

Soil pH was varied by adding H_2SO_4 (to obtain lower pH levels) or Na_2CO_3 (to obtain higher pH levels) to an acid clay soil (pH 4.7.) diluted by ½ with pure quartz sand.

Experiments were also conducted to evaluate the interactions among the three pathogens and the three environmental factors under study. In this part of the work three soil temperatures, three soil moisture levels, and three soil pH levels were used with all possible combinations of pathogens. Soil moisture and pH were controlled as described above, and soil temperatures were controlled by use of refrigeration coils, soil heating cables and regulation of greenhouse temperature.

All pathogens were grown on potato-dextrose agar. The cultures were fragmented in a Waring Blendor and were mixed thoroughly with the soil before healthy rooted cuttings were transplanted into it or were injected into the soil with a hypodermic syringe after the plants had become established. Data on root rot development were usually taken within 3 weeks after the plants were inoculated in order to observe disease development in the various treatments at a point where maximum differences could be seen. Disease severity was rated using a 0-5 index. A plant receiving an index rating of 5 indicated that the entire root system was destroyed.

Results

The Temperature Effect—Soil temperature was found to affect significantly the development of each of the poinsettia root rots in soil of pH 7.0 when relative high soil moisture was maintained. Under these conditions root systems inoculated with *Thielaviopsis* were almost completely destroyed within about two weeks at 63° F. At 55° F., root rot was severe, but not as severe as at 63° F. At both 71 and 79° F. root rot was more severe than at 55° F., but disease was markedly decreased at 86° F. In these experiments, however, disease was initiated at 86° F. and *Thielaviopsis* was isolated from plants held constantly at this temperature. It appears that *Thielaviopsis* at high temperatures may be more destructive than previously believed. Nevertheless, high summer and fall temperatures probably serve to limit development of this disease early in the growing season.

Pythium root rot was most severe at low temperatures. With *Pythium*, as with *Thielaviopsis*, more disease developed at 63°F. than at 55°F., but at 71°F disease severity was greatly decreased. At 79 and 86° F. only a trace of Pythium root rot developed, whereas Thielaviopsis root rot caused considerable damage at 79° F.

The damage caused by *Rhizoctonia* appeared both as a root and stem rot. Both rots show a similar degree of development with respect to soil temperature. This pathogen caused very little damage at temperatures below 71° F. At higher temperatures, disease development was rapid and increased almost directly with increases in soil temperature up to 86° F., the highest temperature employed.

The Moisture Effect—At the lowest soil moisture level tested (near 30% MHC), *Thielaviopsis* was quite destructive, from ¼ to ½ of all roots of inoculated plants were destroyed within three weeks after inoculation. Root rot was significantly increased by increasing soil moisture up to 60 to 70% MHC; at this level, anywhere from half to all of the roots of plants in infested soil were destroyed during the experimental period. Thielaviopsis root rot severity was not significantly altered by increasing soil moisture from 60 to 70% MHC to 80 to 87% MHC.

Pythium root rot development was only slight at soil moisture levels between 30 and 40% MHC and was only moderately increased by increasing the moisture level to 50 or 65% MHC. When soil moisture was increased from the latter level an abrupt increase in disease severity was noted and an average of about ¾ of all roots of inoculated plants were destroyed within about two weeks at soil moistures above 80% MHC.

At the lowest soil moisture tested (near 30% MHC), damage caused by *Rhizoctonia* was most severe. There was an almost linear inverse relationship between disease development and soil moisture content between 36 and 80% MHC. At the latter moisture level *Rhizoctonia* caused virtually no damage to poinsettia in these experiments, while at the lower moisture level plants were sometimes rendered worthless within a seven day period.

The pH Effect—Thielaviopsis root rot of poinsettia was significantly reduced in soils with a pH below 5.9 and pH levels below 5.3 resulted in good control of the disease, but did not eliminate it. Soil pH levels between 6.5 and 8.8 were very favorable for disease development.

Pythium root rot was also favored by high pH levels and reduced at low pH levels. At pH 4.5 very little damage was observed, but as soil pH was increased there was an almost linear increase in root rot development up to between pH 6.8 and 7.5, within and above this pH range Pythium root rot was severe.

Several experiments were conducted with *Rhizoctonia* in which root rot severity at all pH levels tested remained at a low level. A later experiment was conducted in which a high degree of infection was obtained over a pH range between pH 4.5 and 7.5. Based on the latter experiment it appears that soil pH does not have any great influence upon development of Rhizoctonia root and stem rots.

A summarization of the data on the influence of soil temperature, moisture, and pH upon development of the poinsettia root rots is given in Fig. 1. An examination of this graphical summary will show that no single environmental factor tested can be manipulated in such a manner as to give a great reduction in disease development in the presence of all three pathogens. Further examination, however, shows that low soil temperature reduced damage caused by *Rhizoctonia*, low soil moisture gave fairly good control of Pythium root rot, and low soil pH reduced damage caused by *Thielaviopsis* and *Pythium*. It should be noted that soil pH gave a quarter reduction of Thielaviopsis root rot than did any level of either soil temperature or moisture. It appears that a combination of low soil temperature (about 65° F.), low soil moisture (below 50% MHC), and low soil pH (below pH 5.3) should result in a favorable combination of environmental factors for reduction of the poinsettia root rots.

Interactions of Pathogens and Environmental Factors—Since the pathogens may occur in any combination, it becomes necessary to determine the effect of one pathogent upon another in a disease complex; it is also necessary to determine the interactions between environmental

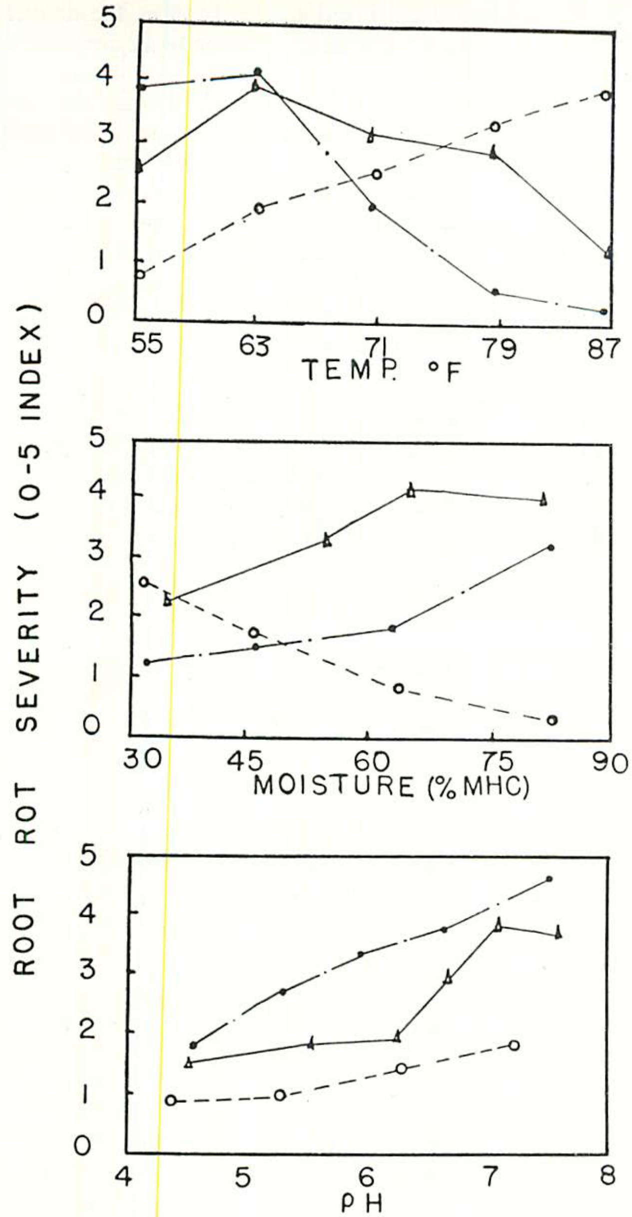

Figure 1. The influence of soil temperature, moisture, and pH upon development of the poinsettia root rots caused by *Thielaviopsis basicola* (Δ——Δ), *Pythium ultimum* (●——·——●), and *Rhizoctonia solani* (O— — — — —O).

factors, and the interactions between environmental factors and pathogens with respect to disease development. An experiment was conducted to determine if in fact a combination of low soil temperature, low soil moisture, and low soil pH is the best combination of environmental factors to employ to obtain minimum disease development regardless of the combination of pathogens present.

In this experiment three levels of soil moisture, temperature, and pH were employed in all possible combinations with all possible combinations of pathogens. This resulted in 216 different treatments, and 6 replicates were employed in each treatment. Soil temperatures of 65, 75, and 85° F., soil moisture levels of 45, 64, and 90% MHC, and soil pH levels of pH 4.5, 6.5, and 7.5 were selected. Data on root rot development were taken 19 days after inoculation.

Analysis of the experimental results revealed 20 significant interactions within and among environmental factors and pathogens, but in this experiment minimum disease developed in the treatments which received, in combination, a soil temperature of 65° F., a soil moisture content of 45% MHC, and a soil pH of 4.5. Plants grown under this combination of environmental factors received an average disease index below 1.8 even when all three pathogens were present. The controlling effect of low soil pH upon disease development was evident throughout most treatments in the experiment. Statistical analysis of the results of all treatments revealed that soil temperature, moisture, and pH all had a significant effect upon root rot development. The most important factor with respect to disease control in this experiment was soil pH. This was followed by soil moisture and temperature respectively.

Conclusions

Experimentally the poinsettia root rots whether caused by *T. basicola, P. ultimum or R. solani* or any combination of these pathogens can be greatly reduced by manipulation of the soil environment. Maintenance of a low soil pH (between 4.5 and 5.3), a low soil moisture (between 30 and 45% MHC, and a low soil temperature (between 63 and 65° F.) proved to be the best combination of environmental factors for retardation of root rot development.

Soil pH was the most influential factor with respect to disease control in this work, and this highly significant pH effect can be attributed mostly to the reduction in damage incited by *Thielaviopsis* at pH levels below pH 5.9. The controlling influence of low soil pH upon development of Pythium root rot was also important.

Low soil moisture played a major role largely because of its controlling influence upon damage incited by *Pythium* and to a certain extent that incited by *Thielaviopsis*. It should be noted, however, that low soil moisture increased the severity of disease incited by *Rhizoctonia,* but in the presence of low soil temperature Rhizoctonia damage was suppressed regardless of the moisture level employed.

In experiments in which environmental factors were varied individually with each pathogen and the experiment in which the three environmental factors were varied simultaneously in the presence of all combinations of pathogens, the same conclusions were reached. Low soil pH, moisture, and temperature was the most favorable combination of environmental factors for reduction of root rot development.

It is hoped that these results can be used on a practical basis in the future in the form of a supplement to the "complete sterilization program" which is now recommended, but before this can become a grower recommendation further work has to be done under conditions which will more closely approximate those which the grower will be able to obtain in terms of controlled environment. Also, the effects of the various combinations of environmental factors, which tend to reduce root rot development have to be evaluated with respect to the commercial quality of the plants. There is a good possibility, however, that "controlled soil environment" in combination with a "complete sterilization program" may hold the key to more profitable poinsettia production.

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Summary

Low soil pH (below pH 5.3) reduced root rot severity incited by both *Thielaviopsis basicola* (Berk, and Br.) Ferr. and *Pythium ultimum* Trow. Low soil temperature (below 71° F.) had a controlling influence on root rot incited by *Rhizoctonia solani* Kühn. Pythium root rot was reduced in the presence of low soil moisture regardless of the levels of other environmental factors employed. Of 216 combinations of environmental factors and pathogens investigated, a combination of low soil pH (pH 4.0 to 5.3), low soil moisture (below 45% MHC), and low soil temperature (about 65° F.) resulted in minimum disease, regardless of the pathogen or combination of pathogens present.
