Poinsettia Trouble a Result of Root Rot

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During the past two or three seasons those who grow or handle poinsettias have noted an unusually high proportion of plants which were severely damaged or entirely unfit for sale. The symptoms included some or all of the following characteristics: one or more plants in a pan greatly dwarfed (Figs. 1 and 4); leaves small, narrow or crinkled (Figs. 1 and 2); leaves pale and sometimes showing bronzed areas between the veins (Fig. 2); flower head irregular, often quite one-sided; floral bracts extremely narrow; severe premature leaf drop, often leaving the stem completely bare below the flower head (Fig. 5); stem developing an abnormal reddish color. In most cases which were called to our attention the symptoms began to be evident soon after panning, though in some cases the plants remained apparently normal until mid-November, when severe leaf drop developed rather rapidly.

Numerous theories were advance to account for the poinsettia trouble, including deterioration of stock plants, virus diseases, deficiency of one or more nutrient elements, and chilling of the plants. It is conceded that such factors may in some cases be primarily or even solely responsible for the trouble observed. It is also recognized that such factors may greatly influence the development of the root rot which we have found so consistently associated with the numerous diseased specimens submitted for diagnosis. However, it is our opinion that in an overwhelming majority of cases the disease symptoms described above are a direct consequence of root rot, with the other factors playing, at best, a minor role. It is the purpose of this paper to give a progress report of our findings since the results have been quite conclusive, since the disease can be controlled, and since the control program for the 1951 Christmas crop must be initiated now.

Root rot caused by fungi

With a single exception, root rot was present on all specimens submitted to us. In some cases only a small proportion of the total root system showed rot, but in most cases the rotting was extensive. Often, the roots which had grown out into the panning soil were only slightly affected whereas roots in the original soil ball were extensively rotted. In many cases numerous longitudinal black cracks were present in the stem below the soil line (Fig. 3). The black color was caused by masses of spores of one of the root rot fungi in the cracks.

Microscopic examination and isolation showed that in all but one of the cases of root rot the black root rot fungus, Thielaviopsis basicola, was present. In a single case from Missouri, a distinctly different

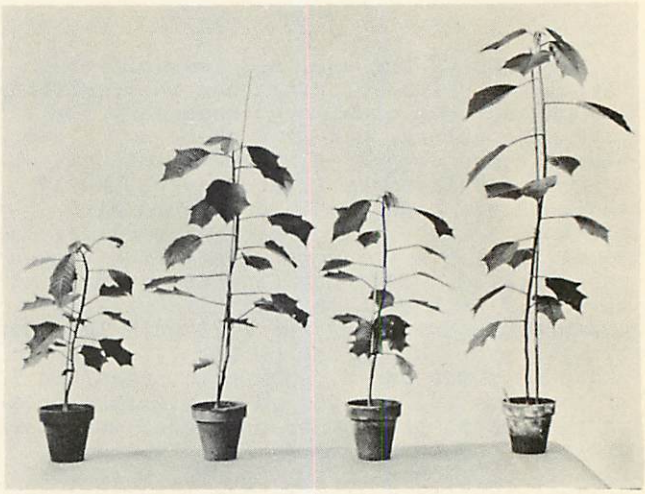

Fig. 1. First and third plants grown in Thielaviopsis infested soil from commercial greenhouse; second and fourth in same soil which was first steam sterilized. First pair are average plants and second pair are tallest plants of respective groups. Plants started in hot weather; root rot delayed and no abnormal leafdrop, but notice overall dwarfing and narrow, curled upper leaves of diseased as compared with healthy plants. Cuttings mid-July; photo Oct. 24, 1950.

root rot fungus, known as Pythium, was recovered and Thielaviopsis was not found. Many other fungi, including Fusarium, Cylindrocarpon, and Rhizoctonia, were also isolated from many specimens so that inoculation tests were necessary to determine which, if any, of the fungi was causing the trouble.

Inoculation studies

A number of inoculation experiments have now been conducted which show conclusively that typical root rot and all of the symptoms shown by the specimens may be caused by the black root rot fungus, Thielaviopsis basicola. A single experiment, involving inoculations with all of the fungi isolated, will be described.

Poinsettia cuttings which had been rooted in sterilized vermiculite were potted in 3-inch pots of sterile soil which had been inoculated with pure cultures of Thielaviopsis, Fusarium, Pythium, Cylindrocarpon, and Rhizoctonia which had been obtained from the diseased roots of poinsettia specimens. In addition, the roots of some cuttings were dipped briefly in a water suspension of spores of Thielaviopsis prior to potting in sterile soil. As checks, a group of cuttings was potted in uninoculated sterile soil. Seven plants were used in each series and the pots

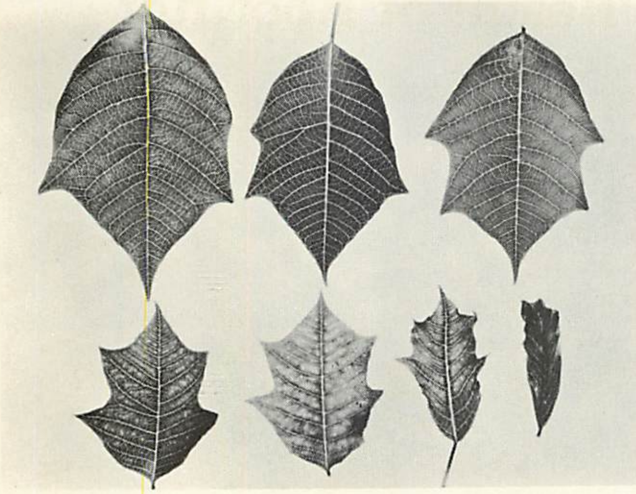

Fig. 2. Typical leaves from plants of experiment shown in Fig. 1. Upper, healthy; lower, diseased. Notice narrowing, curling, interveinal yellowing, and dead tissue between veins of diseased leaves. Symptoms are variable, being affected by amount of root rot, time of year, seasonal characteristics, and other factors.

were placed on inverted sterilized flats on the greenhouse bench with sufficient space between to minimize cross-contamination by splashing. Since the number of available plants was limited, all of the good ones were used in the six inoculated series, leaving only very poorly rooted or unrooted ones for checks.

Within 2 weeks all of the Rhizoctonia-inoculated plants were dead, showing typical symptoms of Rhizoctonia stem rot, which is distinctly different from the root rot here considered. At this time the Pythium series looked bad, with the leaves somewhat droopy and little evidence of new growth; the plants in soil infested with Fusarium, Cylindrocarpon and Thielaviopsis looked perfectly healthy; those with the roots dipped in Thielaviopsis suspension looked abnormal, but were better than the Pythium series; while the checks looked very bad indeed.

Four weeks later (6 weeks from the start) the situation had changed completely. All plants of both Thielaviopsis series were now showing severe symptoms, with marked reddening of the stems, extensive root rot, abundant leaf drop, and almost no new growth. The Pythium plants were not much better, being dwarfed and showing extensive root rot, but they had not lost many leaves and were showing slight evidence of recovery. The Fusarium and Cylindrocarpon plants had at no time shown disease symptoms and were growing vigorously. The check plants, although off to a very poor start, had finally taken hold and were growing very well, with no evidence of root rot. The trend shown at this time continued, with the differences becoming more pronounced. The plants were photographed 11 weeks after the start of the experiment (Figs. 4 and 5).

It should be emphasized that in the above test and others similar to it all plants were treated alike except for inoculation of the soil or roots. All cuttings were taken from the same stock plants, the soil was originally uniform, and the plants were at no time exposed to low temperature or chilling since the minimum greenhouse temperature was approximately 65°F. The nutrient levels and balance may not have been optimum for poinsettias, but the initial condition of the soil was the same and all fertilizer applications were made at the same time to all plants. However, no symptoms typical of the disease under consideration developed on any plants except those where either Pythium or Thielaviopsis was present. In the Pythium series <u>some</u> of the symptoms appeared, but only in the Thielaviopsis series did <u>all</u> of the symptoms appear.

Source of Thielaviopsis

The fungus Thielaviopsis basicola is very widespread in nature, occurring from the Atlantic to the Pacific and from Canada to

Fig. 3. Longitudinal cracking of below-ground portions of stems of plants infected with Thielaviopsis root rot. The narrow cracks are filled with black resting spores of the fungus. Roots extensively rotted.

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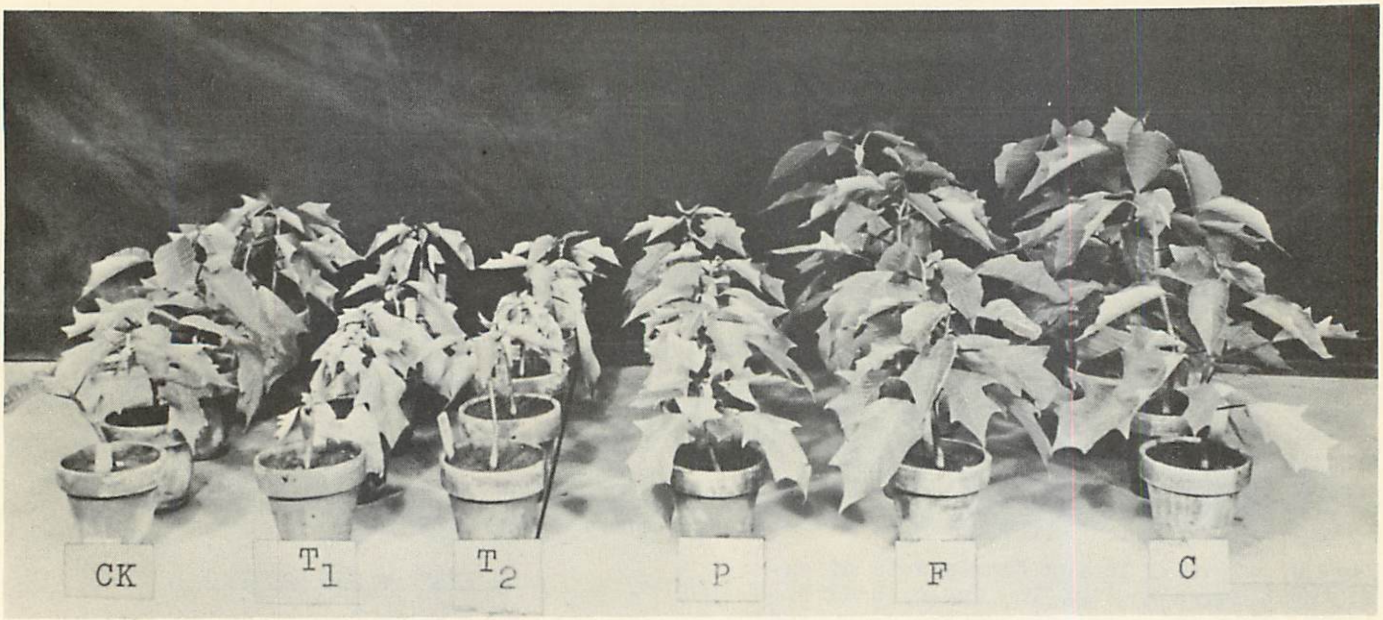

Fig. 4. Five of the seven plants from each of the soil-inoculation series in experiment described in text. Left to right: checks in sterilized soil (Ck); roots dipped in Thielaviopsis spore suspension (T_1); soil inoculated with Thielaviopsis (T_2), Pythium (P), Fusarium (F), and Cylindrocarpon (C), respectively. Note: checks, poorest of lot after 2 weeks (see text), are now growing normally; Thielaviopsis plants chlorotic, droopy, badly defoliated; Pythium plants chlorotic and dwarfed but not droopy or defoliated; Fusarium and Cylindrocarpon plants perfectly healthy -- these also had perfectly healthy roots and are more representative checks than the intended checks. Started in cool weather, Thielaviopsis quickly caused extensive root rot and severe top symptoms. Rooted cuttings potted February 21; photo May 7, 1951. Plants grown under long days.

the Gulf of Mexico. It has been reported on the roots of more than 100 plant species but is best known as the cause of the serious black-root-rot disease of tobacco. It attacks many ornamentals and has caused serious trouble on violets (Viola sp.), snapdragons, and geraniums. Although it is probable that strains of the fungus differing somewhat in pathogenicity could be found, there is at present no evidence that a specific strain is involved in the poinsettia disease.

The original source of Thielaviopsis in any given greenhouse might be exceedingly difficult to trace. It could be introduced with most any batch of field soil or it might come along as a free rider on any one of many different sorts of plants purchased from other sources. The possibility of introduction on poinsettia stock plants from the Pacific Coast has been suggested. This unquestionably does occur and probably has occured as long as poinsettia stock has been shipped from one part of the country to another. Nevertheless, it would be unwarranted to blame the introduction of the fungus on California stock without first eliminating the innumerable opportunities for introduction from one's own backyard. However, as will be seen later, this possibility cannot be ignored.

Once the fungus is introduced into a greenhouse. and it is safe to assume that it is now present in most pot plant ranges, there are several ways in which it may be perpetuated and increased. First, however, let us state that it is highly improbable that the fungus could be present in cuttings even though the roots of the stock plants were severely infected -- it is not that kind of fungus. It could, however, be present on the cuttings if soil were splashed up onto the shoots during watering operations. It could also be present in the propagating beds if old sand or vermiculite were used without sterilization or if old benches were filled with propagating medium without first sterilizing or disinfecting the boards. If the fungus once got into the propagating medium it could easily build up if successive batches of cuttings were rooted without sterilizing between batches.

A very likely source of contamination is in dirty 2 1/4 or 2 1/2 inch pots, particularly if such pots had previously been used for poinsettias or geraniums. Studies on the black-root-rot of tobacco have shown that Thielaviopsis will resist long periods of drying.

A dirty potting table may well be the source of contamination. This possibility is obvious but it is commonly overlooked.

Perhaps the most common and serious source of contamination can be found in the gravel, cinders, or soil upon which the pots are placed. This would be particularly important with the small pots because of the confined root system and the closeness to the source of contamination. Circumstantial evidence in several houses last season pointed strongly to this source of trouble, and the presence of the fungus in the cinders was demonstrated. More recently it has been shown experimentally that the roots can readily pick up infection from the cinders. It was found that the roots growing into contaminated cinders may become heavily infected before they have grown more than 1/2 inch through the drainage hole. This was observed 3 weeks after small healthy plants in sterilized soil in sterilized 3 inch pots were placed on contaminated cinders. Although some growers may change the gravel or cinders frequently, many do not and the benches may be used for several seasons with a constant succession of susceptible crops. Alternately using the same space for poinsettias and geraniums, both of which are susceptible, is a common practice. This not only perpetuates, but favors the increase of Thielaviopsis in the substrate.

Control of root-rot

The above observations and investigations, while not complete, give us the basis for an effective program for control of the poinsettia root rot disease complex. Such a program is here outlined.

1. Sterilize the propagating benches and the sand or vermiculite contained therein with steam or hot water, being certain that the temperature attained is high enough (160°F.) and maintained long enough (at least 1/2 hour) to sterilize the bottom and sides as well as the rooting medium itself. If sterilization is impossible, empty the bench, scrub the sides and bottom thoroughly, spray or paint with ferbam (Fermate, Karbam Black, etc.) suspension containing 2 or more tablespoonfuls per gallon plus about a half teaspoonful of a good wetting agent (DuPont Spreader, Orvus, Dreft, Swerl, etc.), and fill with new sand or vermiculite. Changing the medium between batches of cuttings would do no harm but may not be necessary if the original job is well done.

2. Dust the base of the cuttings with ferbam before sticking in the sand. This is done best by laying the cuttings out on the table, dusting lightly with the aid of a small plunger type duster, then turning the cuttings over and dusting the other side. The ferbam may be used straight or diluted 50-50 with talc.

3. Use new pots for the rooted cuttings. If old pots are used, they should be thoroughly cleaned and soaked for 10 minutes or more in a 1 to 50 formaldehyde solution (1 volume formaldehyde to 50 volumes water) and dried before use. Dipping in ferbam would doubtless be effective but since it does not go into solution the suspension would have to be frequently stirred or agitated and there is some question as to whether the surface would be adequately coated if the pots were nested.

4. Thoroughly scrub the surface of the potting bench and swab with either 1 to 50 formaldehyde or ferbam suspension before loading with soil. Do this before every potting session.

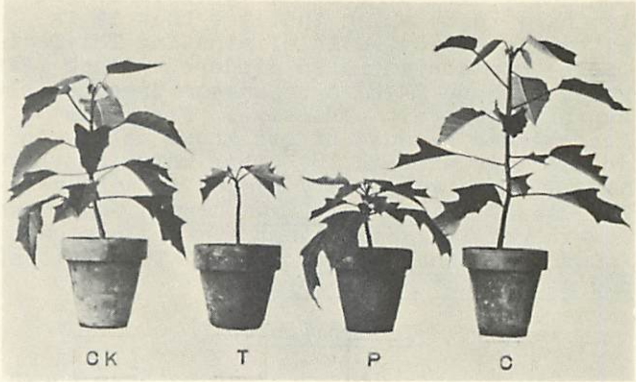

Fig. 5. Typical plants from the check, Thielaviopsis, Pythium, and Cylindrocarpon series shown in Fig. 4. Note defoliation of Thielaviopsis plant and equal dwarfing but lack of defoliation of Pythium plant. Cylindrocarpon caused no injury.

5. If at all possible, sterilize all potting soil. If sterilization is not possible, the use of "virgin" field soil is recommended. Furthermore, if all other steps in this program cannot or will not be carried out it is the writer's opinion that it would be preferable not to sterilize the potting soil, but if all other steps can be and will be taken, sterilization of the potting soil is definitely to be recommended.

6. Sterilization or treatment of the gravel or cinders on the benches is thought to be one of the most important steps in the control program. If the gravel or cinders are reasonably clean, steam sterilization in place would be best, taking care that the side boards are thoroughly heated. Where steaming is impractical the gravel or cinders could be sterilized by drenching with copious quantities of near-boiling water. If the gravel or cinders are very dirty or if neither steam nor hot water is available the benches should be thoroughly cleaned out and swabbed down liberally with either 1 to 50 formaldehyde or ferbam suspension (Fermate, Karbam Black, etc.) at 1 1/2 to 2 lbs. per 100 gallons or painted with Cuprinol before refilling with clean gravel or cinders. After filling, the gravel should be thoroughly sprayed with Ferbam suspension.

7. Since it is possible that the roots of stock plants may carry Thielaviopsis, the soil in which they were grown should be sterilized before reuse, and, if pot-grown, the gravel or cinders on which they were placed should be sterilized or thoroughly drenched with ferbam suspension before placing other potted plants thereon. Dipping the stock plants in ferbam suspension prior to planting might be helpful in eliminating surface contamination but this practice has not been tested.

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Use of ferbam based on preliminary tests

The use of ferbam suspension for drenching the gravel or cinders is based on preliminary tests which indicate that it is extremely effective in eliminating Thielaviopsis from contaminated cinders. Zineb (Parzate, Dithane Z-78) and Semesan drenches also appear to be very effective. Ferbam is recommended because of its known safety on poinsettias whereas the other materials have not yet been adequately tested in this respect. The use of a copper sulfate drench, which we tentatively suggested last winter, has been found to be ineffective against Thielaviopsis and should not be employed.

In conclusion

Experiments discussed above have shown that root rot, caused by the fungi *Thielaviopsis basicola* and Pythium sp., is in all probability the major contributory cause of the poinsettia disease which has been so damaging during the past 2 seasons. Other factors may in a few cases have been solely responsible for trouble, and in all cases such factors have no doubt influenced the development of root rot and the expression of disease symptoms. Johnson and Hartman (1), working with Thielaviopsis root rot of tobacco, have shown that the severity of root rot increases very greatly as the soil temperature falls below 75°F. Preliminary tests here have indicated that a similar relation exists with Thielaviopsis on poinsettias. This may be a consequence of increased aggressiveness of the parasite at lower temperature, but is more likely related to the fact shown by Post, Bing, and Horton (2) that little or no root growth occurs even with healthy plants at temperatures of 60° or below. Under such conditions the loss of a given amount of root tissue would have much more effect on top growth than the loss of the same amount of root tissue at higher temperatures where new roots are developing rapidly. Thus, if young plants with infected roots are grown at low temperature the roots may be severely invaded, typical top symptoms develop, and the plants might show little or no recovery after panning. If, on the other hand, the young plants and pans were held at high temperature until leaf and bract formation were well along, and the temperature were then lowered to hold the plants back for Christmas, root growth would be restricted, Thielaviopsis rot would continue or perhaps accelerate, and the plants might well respond by yellowing and dropping their leaves. Regardless of temperature effects, however, it is the writer's firm belief that if the root rot fungi are eliminated the trouble recently experienced will be almost completely eliminated.

It should be pointed out that Thielaviopsis root rot (which we believe to be the principal one involved) is *not* new, nor have we ever claimed it to be. The connection between Thielaviopsis root rot and an abnormality of poinsettia stock plants was suggested by Tilford (3) in 1941, but this relationship was not proved and the writer knows of no record of previous recognition of its relation to the disease of the flowering crop here discussed. The Pythium root rot has been known for many years and was recently described fully by Tompkins and Middleton (4). Results of our inoculation studies differed from their's, however, in that in their tests Pythium attacked the stem as well as the roots and almost always caused death of the plants within 4 weeks after inoculation. In our tests the Pythium used attacked only the roots, and the single plant which had died after 11 weeks was proved by isolation to have been infected with Rhizoctonia which had apparently spread over from the adjacent Rhizoctonia-inoculated pots. The identity of our Pythium, and its distribution and importance in comparison with Thielaviopsis have not been determined.

A bright side to this story is the fact that the measures suggested here for control of Thielaviopsis root rot have also been found to be highly effective against both the Pythium and Rhizoctonia root and stem rots.

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Your Editor,

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