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Will Black-Spot Infect Misted Roses?

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At one time the black-spot disease of roses caused by *Diplocarpon rosae* was the most important disease of roses grown under glass. Great efforts by research workers during the 1930's and 1940's practically eliminated black-spot as a serious problem in greenhouses. The major reason for this was that insecticides were found which would control spider mites without the necessity for syringing. By syringing, growers were providing the conditions necessary for infection, sporulation and spread of the pathogen. Lyle (1938) found that infection developed only if the foliage remained wet for at least six to seven hours, or if the spores were first wetted and then subjected to an extremely high relative humidity so that germination and penetration could take place. Lyle also stated, as have others, that the principle reason for the severity of black-spot was that the spores were disseminated by syringing for mite control, thus causing great losses of foliage with subsequent decreases in production and quality.

With increased use of insecticides effective against mites, the practice of syringing was gradually dropped and the reports of serious outbreaks of black-spot became less frequent. Very recently, however, interest in this disease has returned with the introduction of mist growing of roses. This article is concerned with the effects of mist on the spread, initiation and development of the black-spot disease of roses under mist and some possible commercial consequences. A brief summary of this work was presented to the Floriculture section of the American Society of Horticultural Science at Storrs, Conn., in August, 1956 ("Effect of mist on inoculation, infection and development of the rose black-spot fungus", R. O. Miller and A. W. Dimock).

Experimental

The first experiment to be discussed was designed to determine whether the black-spot fungus would be able to infect plants under mist and, if so, how the amount of infection might compare with that under conditions known to be favorable for the fungus.

Rose cuttings approximately seven weeks old and growing in three inch pots were inoculated with a suspension of spores of *D. rosae.* The inoculum was obtained by shaking infected leaves, which had been incubated in a moist chamber, with distilled water. Altogether, 64 plants were inoculated and divided into eight groups of eight plants and treated as follows:

1. Inoculated and placed under mist immediately.
2. Inoculated and placed on dry greenhouse bench without mist.
3. Inoculated and placed under mist after 12 hours in a moist chamber.
4. Inoculated and placed on dry greenhouse bench after 12 hours in a moist chamber.
5. Inoculated and placed under mist after 24 hours in a moist chamber.
6. Inoculated and placed on dry greenhouse bench after 24 hours in a moist chamber.
7. Inoculated and put in a moist chamber for 24 hours. placed on a dry greenhouse bench for six days and then placed under mist.
8. Inoculated and put in a moist chamber, placed on a dry greenhouse bench for 16 days and then placed under mist.

The moist chamber used was a garbage can with one-inch of water on the bottom and wet newspapers under the lid.

By the above choice of treatments it was felt that comparisons could be made between moist chamber conditions which were known to favor infection, and treatment with mist which should provide adequate moisture for infection. Since Lyle (1938) found that the amount of infection increased with the length of time water remained on the leaves, treatments were included for longer periods of time in the moist chamber before removal to the "no mist" and "mist" treatments. The plants were inoculated on November 30, 1955 and the number of lesions counted on December 17. The results of this count are shown in Table 1.

As would be expected, those plants placed directly on the dry greenhouse bench had no lesions, because the foliage had not been wet for the required length of time after inoculation. Those plants placed immediately under mist, although the foliage was continuously wet, showed an average of only 1.75 lesions per plant with a range of 0 to4. In contrast, those plants placed initially in a moist chamber so that the foliage stayed wet for the necessary minimum of nine hours had an average of 44 lesions per plant. Curiously then, even though the foliage was wet for more than nine hours under mist, very little infection resulted. This indicated that some factor other than moisture was influencing the ability of the fungus to infect under these conditions.

A second phase of Experiment one was concerned with the effect of mist on the subsequent development of

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*This work was carried out with the cooperation of A. W. Dimock of the Department of Plant Pathology.

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the disease as opposed to development under normal greenhouse conditions. Seventeen days after Experiment one was initiated, plants from each treatment were switched, either from mist or dry conditions, to the opposite conditions. As an example, four plants in treatment one which had been continuously subjected to mist were placed on a dry greenhouse bench and four plants from treatment two which had been on a dry bench were placed under mist, etc. It was not possible to obtain meaningful numerical data sincle leaf drop was severe in some treatments. Observations, however, showed that yellowing and dropping of infected leaves was much more rapid and severe with all plants on the dry greenhouse bench than with those under mist.

TABLE 1—Average number of lesions resulting from exposure of inoculated rose plants to mist, no mist and moist chamber treatments in November-December experiment.

Treatments	Average No. Lesions per Eight Plants
1. Immediate Mist	1.75
2. Immediate Dry Bench	0
3. Mist after 12 hours in moist chamber	45.75
4. Dry Bench after 12 hours in moist chamber	35.38
5. Mist after 24 hours in moist chamber	43.13
6. Dry bench after 24 hours in moist chamber	55.75
7. Mist after 24 hours in moist chamber, 6 days on dry bench	31.87
8. Mist after 24 hours in moist chamber, 16 days on dry bench	39.25

h.s.d. at 1%=25.51. Averages bracketed do not differ significantly from one another.

As mentioned previously, Experiment one was carried out in November and December. In two separate inoculations made in July, quite different data were obtained. Table 2 shows the results of these trials in which it was found that more infection occurred with plants placed immediately under mist than with plants placed in a moist chamber for 48 hours.

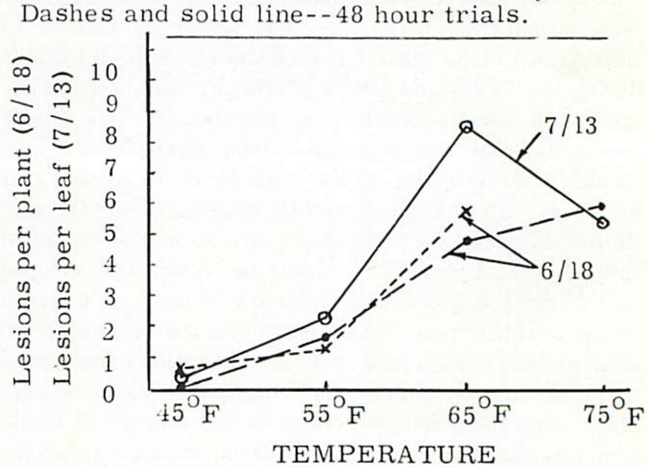
TABLE 2—Relative amount of infection after innoculation and subsequent treatment under mist or in moist chambers in July experiments.

	Plants per treatment	Av. lesions per plant under mist	Av. lesions per plant in moist chamber	Pct. increase, mist over check
Run 1	6	104.0	88.6	17.4
Run 2	4	654.3	408.3	60.2

In experiments carried out in essentially the same manner at two different times of the year, then, conflicting results were obtained. No experimental evidence is offered to explain why this situation prevailed. It is possible, however, that leaf temperatures might have caused these differences. Langhans (1956) has shown that misted leaves may be considerably cooler than non-misted leaves. This could result in leaf temperatures below 60°F in winter which might cause reduced spore germination and infection. Lyle (1938) reported that at temperatures as low as 65°F, or as high as 90°F, germination was less than one percent, whereas, optimum germination, 53 per cent, occurred at 80°F. However, since Lyle (1938) concluded that the greatest effect of temperature on black-spot incidence was its effect on relative humidity, it was decided to conduct temperature studies to determine the effect of temperature on the number of lesions produced. In each of three tests the plants were first allowed to come to equlibrium in chambers at the desired temperature, inoculated, placed in polyethylene bags, and then returned to the temperature chambers. The results are presented in Figure 1.

FIGURE 1

Amount of infection resulting from inoculation of rose plants with Diplocarpon rosae at 4 temperatures. Small dotted line -- 25 day trial Dashes and solid line--48 hour trials.



The plants inoculated June 18 (6/18) and represented by the small dotted line, were maintained at the temperatures indicated for a period of 25 days. This represents the effect on infection *and* development of the disease. The plants represented by the large dashed line, however, were subjected to the indicated temperature for only 48 hours, all plants being placed in the greenhouse after that time. In the July 13 (7/13) experiment the plants also remained in the moist chamber for only 48 hours. The reduced amount of infection evident at 75°F in the July 13 experiment was probably due in part to the excessive drying noted before the end of the 48 hour moist chamber treatment. From this data it is evident that temperature does play an important role in the incidence of black-spot. Since the first experiment was carried out in a greenhouse with fluctuating winter temperatures near 60°F, it is possible that lower leaf temperatures of plants under mist in the December experiments resulted in a reduced number of lesions in contrast to an increased number under mist in July when greenhouse temperatures were higher. More research is needed to clarify this point.

From the experiments here reported it is evident that initiation and development of black-spot can proceed under mist. It is of extreme importance, however, to know whether the disease can also spread under mist. An experiment was designed to try to determine if lesions on infected leaves high on the plant could produce spores which might be carried from dripping leaves and infect healthy leaves below. In one experiment, the plants were divided into four groups immediately after inoculation as follows: 1) four plants were allowed to dry before suspending them

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in racks over large uninfected potted roses under mist; 2) four plants were placed, before drying, in similar racks over uninfected roses under mist; 3) four plants were placed in moist chambers for 12 hours to insure infection before being suspended over uninfected plants under mist, and; 4) four inoculated plants were placed below four healthy plants suspended under mist. At the end of 48 hours all plants beneath infected plants were replaced with another series of healthy plants. The initial plants were then placed in moist chambers for 24 hours. This procedure allowed any spores washed onto the healthy plants during the first 48 hours to cause infection. At the end of 29 days, lesion counts were made. The data were quite variable; therefore, no quantitative statements can be made. Qualitatively, however, it may be said that spores were washed from the inoculated plants onto plants below during the first 48 hours regardless of whether the plants were first dried or were put under mist while still wet. At the end of 29 days numerous lesions were evident on plants from all groups. This gave proof that a complete disease cycle could be completed under mist. There were, however, no lesions on healthy plants suspended 6 to 12 inches above infected plants. A similar experiment carried out immediately following this yielded similar results.

General Discussion

The full practical implications of the results of the experiments reported above would be difficult to assess without further study. It has been established that the pathogen can infect, develop, and produce spores which can cause new infections under mist conditions. There is no evidence, however, that spore dispersal is excessive. Lateral movement from a point source of inoculum was not investigated, but it can be reasoned that in the absence of excessive drafts, very little movement laterally would occur since there is little splashing from mist. From the evidence that the spores move downward, a narrow cone of infection would be expected. In spite of this, little practical application could be made of the results of the experiments without the experience gained from two accidental infections in the Cornell University rose houses.

The first infections were noticed during the summer of 1956. They were located on an outside bench in a house with a crop being grown under mist. Upon further investigation, it was found that lesions were present in several adjacent benches. Several days previous to this, the outside bench (containing the plants upon which the first lesions were noticed) had been syringed for mildew because the mist system was not providing proper coverage and mildew was present. As a result of this syringing, the spores had been spread from the one localized spot to other benches with consequent serious disease development and defoliation. It was definitely known that the disease could be controlled by stopping the mist and applying known control measures. It was of interest, however, to try to control the disease without stopping the mist applications. This was accomplished with the aid of the following three control measures; 1) infected leaves were removed, thereby reducing the source of inoculum; 2) three protective sprays of Maneb (Manzate at 1 lb. to 100 gals.) against new infections were applied three days apart; 3) mist nozzles were rearranged so that adequate coverage resulted and syringing for mildew control was no longer necessary.

The second accidental infection occurred in December 1956 and was also associated with syringing. This outbreak occurred in a different rose house in which one-third of the roses were being misted and the remaining two-thirds were not. Mildew was becoming serious on those plants not being misted and the whole house was syringed. Within a few days after this syringing, black-spot was observed and the point of original infection was found with a pattern of spread similar to that previously mentioned. Again the control measures cited proved entirely effective without stopping the application of mist.

In the light of the experimental evidence obtained and the experience resulting from these accidental outbreaks, it seems likely that although the black-spot disease could be encountered with mist grown roses, it is not apt to be serious. Syringing, with the resulting widespread dissemination of spores, is still the most important cultural practice to be avoided as far as the black-spot disease is concerned.

Summary

Recent attention given to mist growing of floricultural crops has raised the question of possible severe losses by plant disease. It has been suggested that the continually wet conditions might favor dissemination, infection, development and sporulation of pathogenic organisms.

Preliminary studies on the effect of mist on the incidence of black-spot of roses (*Diplocarpon rosae*) have shown that the fungus spores may be carried downward by drip from infected leaves and infect healthy tissue below. In winter, however, the number of lesions produced on inoculated plants placed under mist as compared to those inoculated, placed in a high humidity chamber and then placed on a dry greenhouse bench, was small. In the summer, on the other hand, the reverse was true.

Leaf temperature may be a decisive factor affecting the number of lesions developing on inoculated plants under mist. Experiments have shown that the amount of infection or spore germination drops off markedly below 55°F. and above 85°F. Reduced leaf temperatures under mist thus may have reduced infection in the winter and increased infection in the summer.

Yellowing and abscission of infected leaves developed more rapidly and severely in plants on the dry greenhouse bench than in those kept under mist.

Accidental outbreaks in the Cornell University greenhouses showed that the disease could be controlled on plants being misted and again pointed to syringing as the most important cultural factor favoring the serious development of black-spot.

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