COLORADO FLOWER GROWERS ASSOCIATION

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CONTROLLING POWDERY MILDEW ON ROSES IN GREENHOUSES[1]

Gary S. Cobb and Joe J. Hanan[2]

Each year powdery mildew on roses often reaches epidemic proportions. At any time of the year, mildew is a continual battle. We have found that powdery mildew infestation is closely related to outside climatic conditions, and that, if proper environmental control procedures are followed inside the greenhouse, chemical spraying can be reduced to a minimum. Essentially, our results reinforce the early recommendations given by Cornell, Pennsylvania and California investigators. At certain times of the year, the grower should be alert to initiate timely control measures which include special efforts to reduce humidity and sulfur vaporization.

Preliminary Studies

Humidity and temperature recorders were installed in three rose greenhouses during Spring, 1975. Mildew incidence ranged from zero to massive. Variability of the recorders was such that distinct differences between relative humidity in the different greenhouses were not clear. However, the worst case was where the grower cut off sulfur vaporization, did not heat at night, made no effort to dry out the greenhouse, and did not use a mist system during the day. Humidity records showed a gradual rise toward 100% RH, beginning slightly before sundown and continuing into the evening hours. In this particular example, the crop was white over the entire top from mildew infestation. The grower with no mildew made a deliberate attempt to dry out the greenhouse before sundown by turning off pads and forcing the exhaust fans on. A larger rose range also had a severe mildew problem which could be attributed to lack of timely precautions before mildew had gained a foothold. Sulfur was vaporized in the range, and records showed a relative humidity decrease when heat was turned on.

[1]*Supported by the Joseph Hill Foundation.*

[2]*Graduate student and professor respectively.*

Trial Experiments

During the winter of 1975-76, four, 16×18 ft, fiberglass greenhouses were used for examining the effect of various environmental parameters on mildew incidence. Each house contained 'Forever Yours' and 'Cara Mia' planted in the ground in east-west benches. The roses were watered on demand, with automatic fertilizer injection following Holley and Sadisiviah's recommendations. Each house was temperature controlled independently, heated by steam and cooled by evaporative pad and fan. CO_2 was injected. High and low pressure mist could be provided on demand by a system controlled from humidity sensing elements. The sulfur vaporizer in each house was operated, when required, from a time clock for two hours in the early morning. Continuous vaporization, due to the small house size, resulted in excessive sulfur deposition.

Each house constituted one treatment. At the start of the treatment, a heavily mildew infested plant was placed in each house in front of the aspirator fan. After two weeks, mildew infestation was determined by counting the number of lesions on a representative sample from the houses. The carrier plant was removed and the house returned to zero mildew conditions, with chemical spraying, for eliminating mildew before starting the next series. Clean-up generally required 2 to 4 weeks.

The results are presented in Table 1. The percentage figure under "mist supplied" indicates the minimum humidity level. High pressure mist used 250 to 300 psi pressure, while low pressure employed coarse nozzles at 60 to 100 psi. Note that no treatment resulted in any mildew infection in December and February, during the heavy heating season. The reasons for mildew problems during the spring and summer, and not in the winter, will be covered later.

Series 3 through 6 were most instructive:

1. Sulfur vaporization was highly effective in reducing mildew. (No. 4, Treatments 2 and 3; No. 5, Trt. 3 and 4; and No. 6, Trt. 2 and 4).
2. Turning the pads off before sundown tended to reduce mildew (No. 4, Trt. 2 and No. 5, Trt. 2).
3. Allowing the pads to stay on until sundown or after increased mildew severity (No. 5, Trt. 1).
4. Allowing the mist system to stay on 24 hours tended to increase mildew (No. 3, Trt. 1), but misting during the day apparently was beneficial (No. 3, Trt. 2 and No. 6, Trt. 3 and 4).
5. The relative humidity maintained by the misting system did not seem to have an effect on mildew under our conditions.
6. The time of year had considerable effect on mildew infestation. During the critical periods, no single treatment was sufficient to completely eradicate powdery mildew.
7. The night temperature maintained during the winter apparently had no effect under our conditions.

We may summarize the lessons from these series:

1. Sulfur volatilization is the single most effective mildew control. Recommendations are one vaporizer per 1,000 sq. ft. of greenhouse. Do not use wettable sulfur. A slurry of 1 pint of water and 1 pound of wettable sulfur for each 90,000 cu. ft. can be applied to the steam pipes twice weekly. Any method must be applied continuously regardless of whether you find mildew or not. At CSU, our generators run continuously although they could probably be shut during ventilation.
2. Evaporative pads should be shut off prior to sundown, and ventilation forced on to dry out the greenhouse.
3. Irrigation should not be carried out during late afternoon as this will increase humidity.

Dew Point Temperatures

The differences between Series 1 and 2 and the other series prompted us to look at dew point temperatures. The small experimental house size, which resulted in a large surface-to-volume ratio, and a correspondingly high air infiltration rate, would mean that internal house conditions could be greatly modified by external conditions. Fig. 1 is the average monthly dew point temperature for three years at Fort Collins, Colorado, showing a regular yearly cycle of very low humidity in the winter and increasing rapidly through the spring to a maximum in July or August. As dew point is an absolute measure of humidity, it shows the ability of outside conditions to "dry out the greenhouse". The rise in outside dew point, in April and May, usually coincided with mildew problems in Colorado greenhouses. Similar dew point cycles can be found for other geographical locations, and correlated with mildew infestation. During the winter months, low outside humidity, coupled with heavy heating, dries out the greenhouse so that conditions are not favorable for mildew. In large greenhouse ranges, it would

Table 1: Resume of experiments on controlling powdery mildew of roses in greenhouses by environmental manipulation.

	Experiment		Mist Supplied*	Sulfur	Pad System	Night Temperature	Mildew Count
Dec-Feb	Series 1,	Treatment 1	Low Pressure, 80%	Yes	Not Needed	64°F	0
		Treatment 2	High Pressure, 80%	Yes	Not Needed	64°F	0
		Treatment 3	None	Yes	Not Needed	64°F	0
		Treatment 4	High Pressure, 65%	Yes	Not Needed	64°F	0
	Series 2,	Treatment 1	Yes, 80%	No	Not Needed	62°F	0
		Treatment 2	Yes, 80%	No	Not Needed	56°F	0
		Treatment 3	Yes, 60%	No	Not Needed	56°F	0
		Treatment 4	Yes, 60%	No	Not Needed	62°F	0
Spring-Summer	Series 3,	Treatment 1	Yes (24 hrs.), 80%	No	All Day	62°F	370
		Treatment 2	Yes (10 hrs.), 80%	No	All Day	62°F	198
		Treatment 3	None	No	All Day	62°F	207
		Treatment 4	Yes (24 hrs.), 60%	No	All Day	62°F	162
	Series 4,	Treatment 1	Yes, 80%	No	All Day	62°F	556
		Treatment 2	Yes, 80%	Yes	Off at 4:30pm	62°F	7
		Treatment 3	None	Yes	All Day	62°F	14
		Treatment 4	Yes, 80%	No	All Day	62°F	370
	Series 5,	Treatment 1	Yes, 80%	No	7am-8pm	No Control	416
		Treatment 2	Yes, 80%	No	8am-4:30pm	No Control	18
		Treatment 3	None	Yes	7am-8pm	No Control	11
		Treatment 4	Yes, 80%	Yes	7am-8pm	No Control	64
	Series 6,	Treatment 1	None	No	8am-5pm	No Control	2506
		Treatment 2	None	Yes	8am-5pm	No Control	0
		Treatment 3	Yes, 80%	No	8am-5pm	No Control	151
		Treatment 4	Yes, 80%	Yes	8am-5pm	No Control	54

*High pressure, unless noted; percentages are the minimum relative humidities maintained.

be doubtful that these conditions would be so extreme as found in our experiments. Nonetheless, they show the influence of external conditions on measures to control powdery mildew.

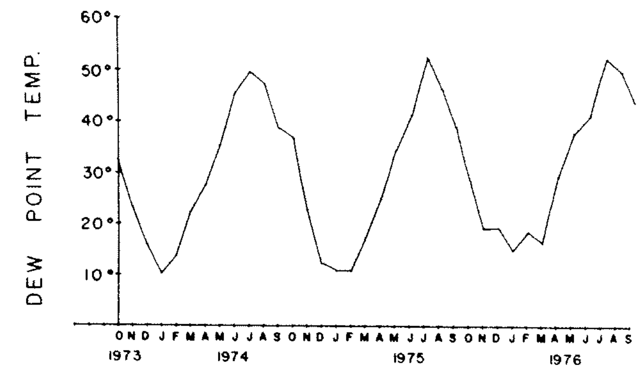

Fig. 1: Average monthly, outside dew point temperature for Fort Collins, Colorado (3 years).

Another manner to indicate critical periods, is to determine the time when it is most difficult to either heat or cool a greenhouse. Assuming that neither heating or ventilation will be required for temperature control when the outside temperature is between 50 to 59°F, Fig. 2 shows the percent of that time. Again, in Colorado, the critical period, when it is difficult to either heat or cool regularly, is during April, May and June, and again during August, September and October. Under these conditions, there is a tendency to leave boilers off, and to leave ventilation idle. A further lesson is suggested:

4. Some heating should be forced during critical periods to dry out the greenhouse. It may be that a short one to two hour period during the night would be sufficient. At CSU, we have encountered mildew when the outside temperatures drop below 60°F and the boiler remains off. A combination of forced heat and ventilation, particularly during the last of April to the first of May, and again in the fall, would be helpful in a program to dry out a large greenhouse range.

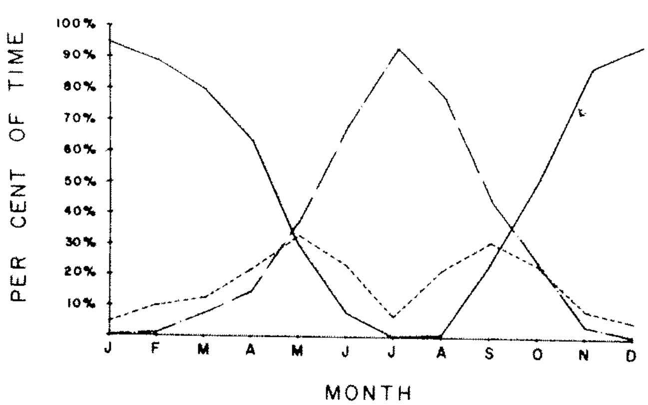

Fig. 2: Percentage of time when a greenhouse at Fort Collins, Colorado, must be heated, cooled or neither.

———————— *Required heating, outside temperatures below 50°F.*

– – – – – – – *Neither heating or cooling, between 50 and 50°F.*

——·——·—— *Required cooling, outside temperatures above 50°F.*

Patterns similar to those in Fig. 2 have been given by Cotter and Walker (1). For Lexington, Kentucky, the 50 to 59°F period is greatest in April and October, but is complicated by a high outside humidity the year around. For San Diego, according to Cotter and Walker's data, the 50 to 59°F period begins to decrease in May, reaches nearly zero in July, August and September, and begins to increase again the middle of September. San Diego has a fairly low outside humidity. Similar patterns can be found for other locations, showing when growers should initiate timely control measures. The latter is particularly important, as lack of problems with mildew tends to make one forget.

5. Environmental control measures should be timely.

Mildew Sporulation

Very little work has been carried out on powdery mildew sporulation. It would appear logical to apply chemical control programs when there is likely to be a large number of spores available. To this end, we installed a spore sampler in one of the test greenhouses to determine any cyclic pattern in spore dissemination. Fig. 3 shows a high number of spores from 12 noon to 4 pm on the average. This could not be considered as diurnal as correlation was found with wind and relative humidity. This suggests late afternoon chemical applications would be most effective. But, spraying too late in the day would tend to increase night humidity, favoring mildew development.

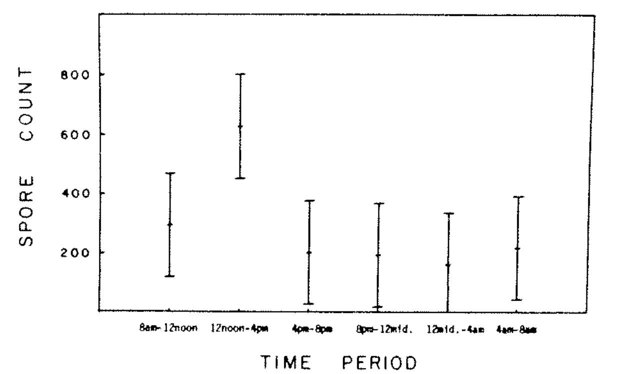

Fig. 3: Sporulation of powdery mildew in greenhouses. The vertical bars indicate how far apart the means must be for statistical significance. If any two do not overlap, the means are different.

Summary

None of the conclusions and recommendations we have obtained are particularly startling, and some variation of them may be found in the literature. Perhaps the application is slightly different with modern heating and ventilation. The results do serve to reinforce the effectiveness of cultural manipulation to reduce spraying to a minimum. We feel that environmental control is cheaper than chemical control. Certainly, chemical control will be very expensive if no effort is made to provide some measure of environmental control in a timely manner. With adequate and timely environmental control, spraying should be reduced to a minimum.

Literature Cited

1. Cotter, D. J. and J. M. Walker. 1968. Strategy of relative humidity and termperature control in greenhouses. Porc. 8th Nat. Agric. Plastics Conf., San Diego, pp 45-50.

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Colorado Flower Growers Association, Inc.
Dick Kingman, Executive Director
2785 N. Speer Blvd., Suite 230
Denver, Colorado 80211

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Direct inquiries to:
Office of the Editor
Horticulture Department
Colorado State University
Fort Collins, Colorado 80523