A RECENTLY OBSERVED EFFECT OF DISEASES ON PLANTS

Prof. Charles E. Williamson,
Ornamentals Research Laboratory

As florists and growers, we are aware of the more obvious effects of diseases such as loss of color in flowers, gall formation, stunting, necrotic areas on leaves and stems, and in certain diseases yellow coloration and abscission of infected leaves. I would like to discuss more fully one of the diseases that cause yellow coloration and abscission of leaves.

The blackspot disease of rose is doubtless familiar to most flower growers. Infected leaves turn yellow and drop shortly after the fungus infection becomes visible. The cause of the yellow coloration and the leaf abscission has long been attributed to a toxin, but the nature of the toxic substance has not been identified. For a thesis problem I undertook to find out something about this toxic substance produced by the blackspot fungus or the blackspot disease. At the start all ideas when investigated led to deadends. Finally, however, the similarity between the symptoms of blackspot and of ethylene gas injury led to some rather interesting observations.

A brief summary of the facts about ethylene may be of interest here. The physiological effects of ethylene on plants were first observed in 1864 when illuminating gas caused injury and death to trees in Germany. The effective constituent of illuminating gas was identified as ethylene in 1901. English workers proved by chemical and biological means in 1934 that ripening fruits gave off ethylene gas. In 1935 certain workers at the Boyce Thompson Institute demonstrated the healthy plant parts such as flowers, seeds, leaves, stems, and roots give off ethylene in minute concentrations. Investigators in the U. S. Department of Agriculture observed in 1940 that decaying citrus fruits caused a more rapid downward bending of tomato leaves than did healthy uninjured citrus fruits. As I will show in just a moment, the downward bending of tomato leaves is a positive indication that ethylene is present. However, the significance of their observation apparently was not recognized by these workers. In this hasty resume we have shown that ethylene can cause injury and death. That it is given off in minute amounts by healthy tissues, and in one case that diseased tissue produced more than comparable healthy tissue.

Now how can we detect and measure these minute quantities? Where ethylene is produced in large amounts, such as by ripening fruits, the gas can be identified by chemical means when the concentration by volume is 25 parts per million or greater. However, when the concentration by volume is one part per million or less--and these concentrations are highly effective physiologically--we rely on biological responses such as epinasty (downward bending) of tomato leaves or the triple response of etiolated pea seedlings. A positive biological response to an unknown gas, though not as conclusive as chemical identification, is now generally accepted as excellent evidence for the presence of ethylene. The etiolated pea seedling method was used in my work to detect and measure ethylene as this method is quantitative and also more sensitive than the tomato leaf epinasty response.

The blackspot disease of rose was investigated more thoroughly since the symptoms were suggestive of ethylene injury. When detached blackspotted leaves were enclosed in gas-tight plastic envelopes with healthy shoots having three leaves each, the leaflets on the three leaves yellowed and dropped within seven days. Similar healthy detached leaves enclosed with healthy shoots having three leaves each caused no change in ten days. The blackspotted leaves apparently produced a gaseous material that caused the healthy leaves to absciss and similar healthy leaves either did not produce such a substance or else produced it in too small amounts to be effective. Further experiments with blackspotted leaves beginning to have a yellow halo about the blackspot lesion, decreased as the leaves became yellow, and ceased when the leaves turned brown.

Next, an experiment was conducted to determine whether the fungus or the diseased tissue was producing the ethylene. The blackspot fungus was grown in pure culture on an agar medium in Petri plates. The cultures were placed in a closed container with pea seedlings. Ethylene was not produced in amounts sufficient to be detected. These results showed that the fungus was unable to produce ethylene from an artificial medium and were suggestive that the fungus when on the rose leaf was not directly producing the ethylene.

The possibility existed that ethylene production by diseased rose leaves was a characteristic of the rose plant. For additional evidence, other rose diseases were tested for the ability to stimulate ethylene production. Mildew or rust on rose leaves caused a very slight increase in ethylene production. Rose anthracnose and brown canker stimulated the production of an intermediate quantity of ethylene. The results with the five rose diseases indicated that the quantity of ethylene produced was dependent upon the fungus involved and was not characteristic of the rose plant. Also a positive correlation existed between the quantity of ethylene produced and the amount of yellow coloration and leaf drop.

To further verify the observations made on the blackspot disease of rose, another disease, shothole of cherry which is characterized by rapid yellow coloration and early abscission of infected leaves, was investigated for the ability to stimulate ethylene production. Here, also, relatively enormous quantities of ethylene are produced by infected leaves.

Next, tests were conducted on many other plant diseases to determine if the phenomenon of ethylene production was characteristic of diseased tissues. Snapdragon rust, chrysanthemum rust, Septoria leaf spot of chrysanthemum, and Alternaria leaf spot of carnation caused moderate quantities of ethylene to be produced. The ray blight of chrysanthemums and Botrytis cinerea on chrysanthemum and carnation flowers produced quantities of ethylene comparable to those produced by the blackspot of rose and the shothole of cherry.

What conclusions can we draw from these observations? Apparently ethylene is rather generally produced by diseased tissues. The quantity of ethylene produced seems to be primarily a characteristic of the pathogen, though there is some evidence of slight differences between different species of plants. The mechanism by which ethylene production is stimulated is as yet unknown. We can speculate that the disease organism causes some type of injury to the plant cells since other types of injury stimulate ethylene production. For example, rose leaves shredded with a knife or heavily infested with red spider mite produced appreciably more ethylene than did healthy rose leaves.

Now, how does ethylene production by diseased tissue apply to the flower business? Certain applications are rather obvious. Ethylene susceptible flowers, such as carnations, should never be stored or shipped in tight containers with other flowers that have a moderate to heavy infection on leaves, stems, or flowers. As pre-packaging becomes more popular, the ethylene effects on flowers probably will become more evident. It is possible that in a small box of flowers, such as orchids, one old flower will give off sufficient ethylene to cause fading and aging of the good flowers. Another possible application relates to general greenhouse sanitation. We all know that occasionally plant debris accumulates in the walks and under the benches. Such material provides an ideal place for Botrytis cinerea to grow and sporulate. In turn, these spores may be blown about to land on blossoms and leaves where they germinate and cause an infection, and such infected plants may be stored, packed, and shipped with healthy flowers. It is conceivable that Botrytis on plant debris could produce sufficient ethylene in a closed greenhouse to cause dropping of blossoms by certain plants. In any event, the fact that diseased tissues do produce ethylene is an additional reason why we should carry out the best possible spray program for disease control.

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