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EXOCORTIS

Effect of Air Temperature and Light on Development of Exocortis in Gynura

S. P. Kapur and L. G. Weathers

Few investigations have been conducted on effects of environment on citrus virus diseases. With citrus infectious variegation virus (CVV), temperatures of 20 to 21° C favored infection of Eureka lemon and *Crotalaria spectabilis* in contrast to fluctuating temperatures of 20 to 35° C (*7, 8, 9, 10*). Plants of *C. spectabilis* developed necrotic rings at 20 to 21° C, but no symptoms at 20 to 35° C. Sour orange and grapefruit plants developed only variegation symptoms at 20 to 21° C, but when kept at 20 to 35° C the plants showed a variety of symptoms. Infection of cucumber by CVV was favored by cool temperatures (*4*). Sesame plants kept at 34° C after inoculation with Satsuma dwarf virus usually developed no symptoms, but showed severe symptoms, even at 36° C, when they were kept at 25° C for at least 8 hours after inoculation and then transferred to that temperature (*15*).

Placing indicator plants in the dark before or after inoculation increased their susceptibility to infection by citrange stunt virus (*18*). Tanaka *et al.* (*15*) found that in midsummer all sesame plants inoculated in the evening with Satsuma dwarf virus became infected, but inoculations made at midday resulted in a very low rate of infection.

No work has been reported on the effect of air temperature and light on exocortis virus (CEV) disease of citrus. Exocortis bark scaling in *Poncirus trifoliata* was directly correlated to increase of temperature and plant growth (*16*). Bark scaling and stunting appeared within 11 and 14 months after inoculation at 35° C and 30° C, respectively. No bark symptoms developed at lower temperatures even after 18 months. Even though bark scaling did not develop in infected *P. trifoliata* stocks at the lower temperature, plants were stunted, suggesting that stunting and scaling are separate virus effects and that variation in symptoms may result from variation in environment as well as virus strain differences (*16*).

We report in this paper effects of changing temperature, photoperiod, and light intensity on symptom development and relative infectivity of CEV in gynura (*Gynura aurantiaca*).

MATERIALS AND METHODS

A severe isolate of exocortis virus was employed for these tests. Plants were inoculated by a modification of the razor-slash method (*5, 6, 17*). Young, developing gynura and citron leaves with symptoms of exocortis were extracted in Tris buffer (0.1 M, pH 9.0) with mortar and pestle. The tissue extract was strained through double layers of cheesecloth before use. Razor blades were dipped in the crude virus CEV extract and drawn diagonally, six to eight times, through the stem of a receptor plant. The cuts were then wrapped with self-adhesive tape. Tools were disinfested between use on differ-

ent plants by dipping in a 1.5 per cent solution of sodium hypochlorite.

Biological activity was determined by the appearance of systemic symptoms on gynura over a 30-day period following inoculation. The total number of "infected-plant days" on five to 10 gynura plants per test comprised the "relative infectivity" value (*14*).

All tests were conducted in growth chambers in which temperature, humidity, day length, and light intensity were controlled. Relative humidity in growth chambers was maintained at 50 per cent. The light source inside the chambers was cool-white fluorescent tubes and incandescent lamps. Plants were grown in 12 hours of light at approximately 1,500 ft-c, in the temperature experiments.

RESULTS

Effects of different constant temperatures on the incubation period and relative infectivity in gynura plants infected with CEV are summarized in table 1. Optimum temperature for development of symptoms was 24 to 30° C, with an incubation period of approximately 12 days. Above 30° C, growth of plants was greatly retarded, and relative infectivity decreased. The incubation period was extended and the relative infectivity and symptom severity markedly reduced when plants were kept below 24° C. No symptoms appeared at 15° C.

When inoculated, symptomless plants kept at lower temperatures were transferred to 24° C or above, symptoms appeared after 10 days, indicating that the symptoms had been masked in plants grown at lower temperatures.

TABLE 1

EFFECT OF AIR TEMPERATURE ON INCUBATION PERIOD AND RELATIVE INFECTIVITY OF CITRUS EXOCORTIS VIRUS (CEV) IN GYNURA AURANTIACA

Air temperature	Approx. incubation period of CEV	Infected/inoculated plants
°C	days	
15	. .	0/10
18	18	2/10
21	15	4/10
24	13	7/10
27	12	8/10
30	12	9/10
33	15	5/10

Effects of varying light intensities on the symptom development and relative infectivity of exocortis virus were studied at a constant temperature of 24° C. Results of these studies are reported in table 2. Light intensities of 500, 1,000, 1,500, and 2,000 ft-c had no significant effect on development and severity of symptoms and relative infectivity. Higher light intensities, how-

TABLE 2

EFFECT OF LIGHT INTENSITY ON RELATIVE INFECTIVITY OF CITRUS EXOCORTIS VIRUS (CEV) IN GYNURA AURANTIACA

Light intensity (ft-c)	Infected/inoculated plants
500	8/10
1,000	8/10
1,500	7/10
2,000	6/10

TABLE 3

EFFECT OF DAY LENGTH ON INCUBATION PERIOD AND RELATIVE INFECTIVITY OF CITRUS EXOCORTIS VIRUS (CEV) IN GYNURA AURANTIACA

Day length	Approx. incubation period of CEV	Infected/inoculated plants
hrs	days	
8	15	6/6
16	20	4/6
24	20	3/6

ever, affected normal growth of plants, which in turn may have induced some reduction in relative infectivity. Plants at 2,000 ft-c were slightly stunted, with less purple pigmentation than normal.

In another experiment, effects of day length on symptom development were studied. Growth chambers were maintained at 24° C with a light intensity of 750 ft-c. Results of this experiment are shown in table 3. One hundred per cent relative infectivity and an incubation period of approximately 15 days were obtained when plants were exposed to 8-hour days and 16-hour nights. With an increase in day length, symptom development was delayed and relative infectivity decreased.

Transferring plants from 16- or 24-hour to 8-hour day length or from 8-hour to 16- or 24-hour day length did not affect symptom severity.

DISCUSSION AND CONCLUSIONS

Variation in temperature and illumination determines whether CEV-infected plants develop severe or mild symptoms or become symptomless carriers. Gynura plants did not develop symptoms of CEV when kept at 15° C after inoculation. Mild symptoms developed in plants at temperatures of 18 to 21° C, and severe symptoms developed at 24 to 30° C. Growth of both healthy and infected plants was markedly decreased above 30° C.

Increasing the temperature of most infected plants to an optimum for plant growth generally decreases the incubation period and increases severity of symptoms and virus multiplication (*1, 12*). Keeping plants at temperatures above 30° C after inoculation decreased relative infectivity of CEV. Weathers *et al.* (*16*), however, found that symptoms of exocortis in *Poncirus trifoliata* increased when soil temperatures were increased to 30° C and above.

The possibility that virus is inactivated in gynura at high temperatures can be discounted. Semancik and Weathers (*13, 14*) showed that the thermal death point for CEV is 140° C. Exocortis virus behaves like the viruses of cucumber mosaic, tobacco necrosis and tomato bushy stunt in that it is more stable at higher temperatures in sap than *in vivo* (*11*).

With CEV in gynura there seems to be a direct relationship between relative infectivity and host growth. At higher and lower temperatures, the growth of gynura plants was decreased, as was relative infectivity. A similar relationship was found with soil temperature and exocortis virus in *P. trifoliata* (*16*). With high soil temperature, symptom severity and host growth increased in *P. trifoliata* plants infected with CEV. It is not known whether higher temperatures would have decreased growth and symptoms.

Increase in relative infectivity when plants were raised under low light intensities and shorter day lengths might be explained by postulating that such treatments increase succulence of plants, which facilitates easy movement of virus from cell to cell (*2*) as compared with movement in hard plants raised under high light intensities. This increased relative infectivity may be partly due to reduced formation of photosynthates that interfere with the ready establishment of virus under conditions necessary for multiplication (*3*).

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